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THE

ELECTRICAL MAGAZINE

AND

ENGINEERING MONTHLY.

VOL. XII.

July—December, 1909.

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PREFACE.

DESPITE the general complaint that orders are few and prices bad, the past year has been full of engineering innovations and discovery. Obvious to the general reader is the progress made in methods of road and rail traction and aviation ; the proved success of reversing oil engines on board ship and the imminent adoption on a working scale of electric motors for propeller driving are indications of sweeping changes pending in marine engineering. In the sphere of fixed machinery and process of factory and workshop there has also been a wealth of invention and discovery ; colossal even in its infancy is the new industry of metallic filament lamp manufacture ; other vastly important fields of labour opened up and being definitely established depend upon the use of electricity for making iron and steel and for the manufacture of nitrogenous salts from the atmosphere.

Reference to THE ELECTRICAL MAGAZINE AND ENGINEERING MONTHLY will show that no valuable part of this great wave of engineering development has been overlooked in its pages, and whenever details and illustrations of any discovery or great engineering work accomplished have been available those have been given.

The object of this journal is to select, obtain, and publish accurate records of practical engineering progress the world over. That the effort to do this as thoroughly as possible is appreciated is borne out by many letters of commendation and an ever-increasing circulation.

December 15, 1909.

THE
ELECTRICAL MAGAZINE
AND
ENGINEERING MONTHLY.

An Illustrated Magazine Devoted to the Electrical, Engineering, Shipbuilding, Iron and Steel Trades.

VOL. XII. 15 JULY, 1909. NO. 1.

THE RHONE FALLS POWER SCHEME.

AT the recent congress at Clermont-Ferraud of the Association française pour l'Avancement des Sciences Professor A. Blondel presented a report on the scheme for generating electric power at the Rhone falls, and transmitting the energy to Paris. The investigation was carried out by Prof. Blondel in conjunction with Messrs. Harlé and Mähl. The following is a digest of the report.

The authors discuss three cardinal points:

A. The power available.

B. The comparative merits of high-tension transmission, (*a*) with continuous current, (*b*) with three-phase current.

C. Justification of the proposal, with special reference to the exceptional length of the transmission line, 400km. (248 miles), and to the very high pressures which would have to be employed.

The Power available.

The average head is estimated at 69 metres (226ft.); the hydraulic power available, considering only the waters of the Rhone and the Arve, would during an average three months be

$$120 \times 69 \times 10 = 83{,}000 \text{ poucelets}$$
or 60 million foot pounds.

This figure may be doubled or even trebled for a few hours every day by drawing on the storage capacity of the lake reservoir.

The average volume of water passing the outlet of the lake at Génissiat is 270 cubic metres. To this must be added other 50 cubic metres from the Arve, and another 10 cubic metres from other subsidiary sources. This gives a total average of 330 cubic metres, or

$$330 \times 69 \times 10 = 228{,}000 \text{ poucelets}$$
or 164½ million foot pounds.

Assuming an overall efficiency of turbo-dynamos of 75 per cent., and taking spare and stand-by plant into consideration, the generating station would be able to supply, in round figures, 150,000kw. to the line. Taking into account the volumetric variation of water supply during the twenty-four hours, the authors reckon on an available output, during low-water periods, of 150,000kw. for two hours, and an average of 53,000kw. per hour for the remaining twenty-two hours.

This would give during the three months of low waters (at 61,000kw. per hour average)	132,000,000
Six months of average supply, not counting floods	650,000,000
Three months of intermediate volume of supply...	228,000,000
Total ...	1,010,000,000

Say 1000,000,000kw. hours per annum.

Choice of Current.

In 1906, when this project was first considered, it was proposed to transmit continuous current at 120,000 volts and 750amp. through a line of 900mm.^{2} (1.4 square inch) section. In view of recent advances the authors now consider 200,000 volts as a feasible pressure, while retaining the previous figures for current strength and sections of conductor. The efficiency of the line is estimated at 90 per cent. under this arrangement. With a three-phase current at 120,000 volts pressure between phases, and with a periodicity of twenty-five alternations per second, the 80,000kw. required for the city of Paris itself could be transmitted with a pressure drop not exceeding 16 per cent. This scheme would permit a comparatively low pressure at the generating station, viz., 12,000 volts, which would be stepped up by transformers to 120,000 volts, and at the far end similar banks of transformers would reduce the pressure again.

The Generating Station.

The power house would be built on the side of the gorge of the river at the foot of the falls, and the arrangement proposed would be similar to the station of the Ontario Falls Power Company at Niagara.

Power would be generated by a number of turbines, each of 14,500h.p., driving either one three-phase alternator, or, if the Thury system is employed, a group of high-tension continuous-current generators.

The turbines might be of the Francis type with double wheels of not more than two metres diameter, and having a speed not exceeding 250r.p.m.

Twenty-six of these double turbines would be placed in a row, the shaft axis at right angles to the river, each pair of wheels being fed by a separate duct. The supply from each duct to the turbine would be regulated by an electrically controlled annular slide valve of the Stoney pattern, while the speed would be regulated by adjustable nozzles. Turbines with horizontal shafts are preferred on account of the superior efficiency of the dynamos, and the avoidance of difficulties with the lubrication of the bearings.

Thury System.—The units would consist of 12,000h.p. turbines, each driving three dynamos having an output of 1000amp. at 2500 volts. Each group, therefore, would have an output of 7500kw. Regulation would be effected by a brush adjusting arrangement, motor driven and electrically controlled, so that the load would be shared equally by each machine. By this means it would be possible to reduce the current output during hours of light load, thus saving losses in transmission.

The regulation of the motors at the remote ends of the line would be effected in a similar way.

Three-phase System.—Each turbine would drive a 10,000kw. three-phase alternator supplying current at 12,000 volts, 25 period. The outside diameter of the stators of these machines would be about 8.5 metres (28ft). In position these units would occupy a space of about 8 metres × 15 metres (26ft. × 49ft.). There would be twenty-four 14,500h.p. main turbines and four 750kw. exciter sets.

The transformer station would be built at some distance from the power house on the high level ground.

From this station four, and later six, aerial feeders (12 and 18 cables) would be erected, carrying the current at 120,000 volts to Paris.

The lines at 30 000 volts would serve Ains and other departments at a less distance, and two 12,000 volt lines would serve the various works in the immediate neighbourhood. All the switch gear control would be situated in the transformer house, the generator, bus bar, and feeder selector switches being actuated by electromotors. All bus bars would be in duplicate, and the switchgear would be so arranged that any generator could be switched on to any feeder either direct or through a bank of transformers. Each bank of transformers would consist of six single-phase units, of which two per phase could be connected in parallel. The transformers would be oil-insulated with water-cooling arrangements. Both the low and high tension sides of the transformers would be protected by automatic oil-type circuit breakers. In case of one line going to earth the whole plant feeding that line would be switched on to one of the other lines, which would carry the extra load until repairs had been affected. All bus bars and switchgear, &c., would be built into isolated brick chambers.

The Line.

The line would be divided into sections of about 150km. each, with disconnecting stations which would also serve for distributing points for various industrial districts. The continuous-current system would require a much lighter construction as regards the standards, &c., which would only have two lines to carry as against twelve, and later eighteen, for the three-phase system. In the latter case the cables would be set at the vertices of an equilateral triangle whose side would measure 3 metres (about 10ft.). Each set of lines would be carried along different routes. According to recent legislation it would be possible to carry the lines right across country, thus avoiding frequent bends and angles.

Comparison of the Two Systems.

The most attractive method, according to the authors, would be to employ the continuous-current system with underground cables. This would be safe and simple. The chief objection lies in the absence of sufficient practical experience with underground cables at such high pressures to justify their use.

On the other hand the objection to an aerial three-phase line lies in the possibility of interruption through a breakdown of the line—a danger which, however, would be greatly minimised by employing four or more lines, each taking a different route but working in parallel. Again the three-phase system gives greater facility in the matter of distribution and reduction of pressure. Transformation by static machines is admittedly more efficient and less costly than by rotary machines, which would be necessary with the continuous-current system. But it must be remarked that the considerable fluctuations in the line voltage with the alternating supply would render the use of motor generators a necessity for lighting purposes, so that the above-mentioned advantage is discounted to a certain extent. For these reasons Prof. Blondel, rather than make any pronouncement in favour of one or the other, leaves the choice of systems open.

Practicability of the Scheme.

Prof. Blondel, in examining the arguments in favour of a transmission scheme under such exceptionally high pressures and with a length of line somewhat in excess of any existing transmission, reviews the question firstly from a technical, and secondly from a commercial point of view.

Justification of the Scheme as regards its Technical Aspect.—Considering the matter of generators and transformers, on the one hand, M. Thury has so improved his machines that he can now build them to give 750amp. at 3500 volts, and he has been able to improve their insulation from earth to such an extent that practically there is no limit to the pressures which may be employed. On the other hand transformers have been built successfully for voltages of 100,000 to 200,000 volts, and what is even more important, circuit-breakers are made which can interrupt the current at these pressures.

Regarding insulators, these have been greatly improved, and can be made to stand 200,000 volts or more under very severe conditions.

No difficulties are to be looked for in the construction of suitable iron lattice-work towers with sufficiently broad bases to give them steadiness.

Great progress has been made in the technics of lightning arresters and other means for dealing with atmospheric discharges, and there has been plenty of experience in this direction for guidance.

Certain cable makers have succeeded in making underground cables with a comparatively thin layer of insulation (5mm. and 7mm.) to stand continuous current at 200,000 volts pressure between core and earth.

Justification of the Scheme from its Commercial Aspect.—The following specially favourable points tend, in Prof. Blondel's opinion, to assure the success of the scheme.

Owing to the large power to be used the cables will be heavy, and can be made of even larger diameter than necessary by using aluminium or copper with hemp cores. This large diameter will have the effect of diminishing the risks of arcing, and will also allow greater spacing of the cable supports without fear of rupturing the conductor, thus reducing the number of weak points (*i.e.*, the insulators) on the line.

In supplying Paris the demand will at once be large and will be a continually growing one. An immediate return is therefore assured. Beside Paris itself a considerable number of places and works situated on or near the line will become consumers. The chances of interruption to the supply are minima, in view of the separate lines and the arrangements at the power station.

Cost of the Scheme.

The general conditions governing the scheme make the use of the very high pressures mentioned essential. This entails a heavy cost on the transmission line. The authors estimate it at 300fr. (£12) per kw. On the other hand, the saving at the generating station is very considerable owing to the possibility of concentrating the whole of the enormous water power of the upper Rhone at one fall. To this is to be added the probability of a number of works springing up in the neighbourhood, and these will absorb some of the surplus power available.

The authors therefore reckon that, with an installation of 240,000kw., the power transmitted to Paris will cost at Paris 330fr. to 350fr. per kw. installed, while the power destined for local works near the falls will cost about 100fr. These figures do not include loss in transmission, taken at 10 to 15 per cent., or charges on the line, so that the ultimate price at Paris will be somewhere about 800fr., which will still allow the water power to compete with steam on account of the cost of coal.

* * *

RECENT PRACTICE IN GEAR-CUTTING.

(Continued.)

Hobs are expensive luxuries, and latterly attempts have been made to go back to the single fly cutter, representing the section of the worm thread, for shaping the wheel teeth. This, of course, involves mechanism for the exact synchronizing of the movements of the wheel blank to that of the cutter as a worm thread. That is, the cutter must traverse the same helical path as the worm thread would do. The cutter is, as regards its shape, a slice cut out of the worm thread, doing duty as a cutting tool. There are various methods by which the movements of cutter and wheel blank are made to synchronize in different machines, but it is enough here to state the principle. One of the first machines of this kind was made by a Stockholm firm. Eberhardt Brothers also make one. In England the type is represented by the machine of Henry Wallwork & Co., Ltd., of Manchester. The manufacturers claim that a more accurate gear can be made than with hobs, and also much cheaper because the cutter generates the teeth of all gears of the same pitch, even though the angles of the teeth may vary, which is not the case with a hob. The single cutter is adjustable to suit any angle or lead of tooth. Hobs can be used if desired, so that the machine enables these to be utilised when they are in stock. The section of the cutter is that of an involute rack tooth with 71deg. of angle, being set in its arbor to whatever angle corresponds with that of the wheel being cut. The axis of the cutter arbor is set in the same position relatively to the centre of the worm wheel which is being cut as the axis of the actual worm will occupy. It is, therefore, fed into

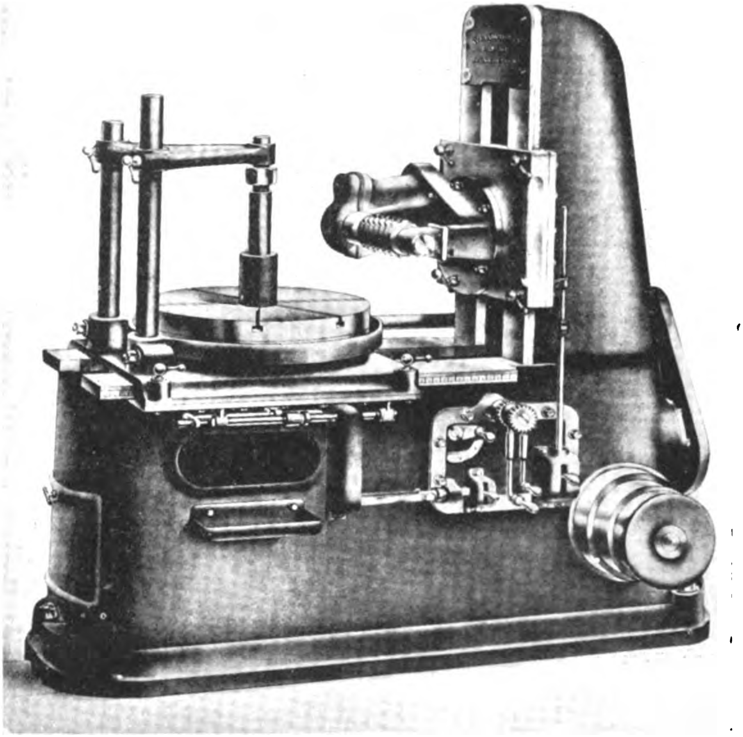

Fig. 12. Gear Hobbing Machine. Henry Wallwork & Co., Ltd.

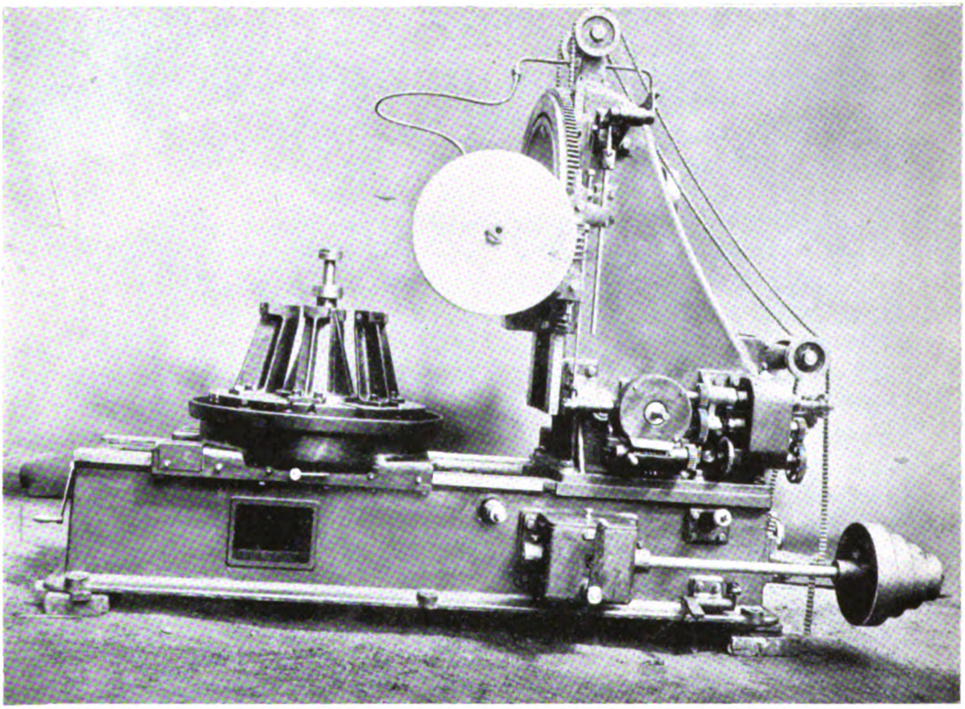

FIG. 13. GEAR HOBBING MACHINE. JOHN HOLROYD & CO., LTD.

the blank by a transverse or tangential movement which takes place during the revolution of the wheel blank and of the cutter arbor. These movements are caused to synchronize by means of two sets of change gears. One set rotates the cutter arbor, the other feeds the arbor tangentially in correct relation to the rotary movement of the blank. The latter movement is obtained in the manner usual to all gear-cutting machines, namely, by a worm and worm wheel. The worm wheel is fixed on the bottom of the work spindle.

A saddle or carriage sliding across the bed permits of adjustment towards or from the centre of the work spindle by a screw and nut, and is clamped by bolts in tee headed grooves. Measurement for centres is taken by a steel scale let into the bed. The slide which carries the bearings for the cutter arbor is fed along the saddle by means of a screw situated centrally, and driven by feed change wheels. Arbors of different sizes are interchangeable in the nose of the cutter spindle by means of a standard taper, and are held in place with a draw bolt. The arbor is supported by a steady close to the cutter. Two cutters are used for double-threaded worms, three for triple-threaded ones, &c., set equidistantly.

The Hindley worm gears, the "globoid" form of Reuleaux, is a curious gear around which much controversy has arisen. Long a mere mechanical curiosity, it is now manufactured accurately by Morse, Williams & Co., of Philadelphia, and is used to a considerable extent for such work as lifts and elevators. The teeth of worm and wheel are both cut, the worm thread being produced by an inserted tooth cutter which represents the teeth of the wheel, and the wheel by a hob which represents and corresponds with the worm.

The cutting of spiral gears is done to a very limited extent in shaping machines, using a special attachment, and a planer tool having the same profile as the space between threads. The vast majority are done on milling machines of the universal type. The cutter is carried on the horizontal arbor, and the wheel blank is carried on an arbor between head and footstocks, rotated through the angle corresponding with the lead by change gears, and pitched by the indexing head. At present the combined spur and spiral gear hobbing machines have entered into serious rivalry with the single cutters used on the milling machines, the work being done more quickly.

Double helical gears cannot be cut with rotary cutters in the same manner as spur gears, and a compromise has been attained in some instances by making the wheels in halves, cutting the teeth on each half, and bolting them together to form double helicals. In the system of cutting introduced by Messrs. Citroën, Hinstin, & Co., of Paris, double helicals are cut out of the solid in special machines using end cutters. Such gears run with extreme smoothness and are quiet. They can be shrouded up to the pitch line on both sides without interfering with the possibility of cutting. The firm can produce double wheels, that is with two double helicals side by side, resulting in four sets of teeth, but for most purposes the ordinary double helical is satisfactory. These gears are employed for much work where rawhide pinions are otherwise considered essential, and they are made in both small and large dimensions, from the gears used for valve motions to those for rolling mills.

Another solution of the problem of cutting double helical gears is that of Messrs. Wüst & Co., of Zurich. Here the difficulty of cutting the teeth through to the centre is solved by staggering them, so that the centres of the teeth on one half of the wheel coincide with those of the tooth spaces on the other half. The appearance of a gear is that of two spiral gears of opposite hand set together. There is an incidental advantage in staggering—that of securing smoothness of running and more freedom from shock, similar to that which obtained in the stepped gears that were the predecessors of the helical

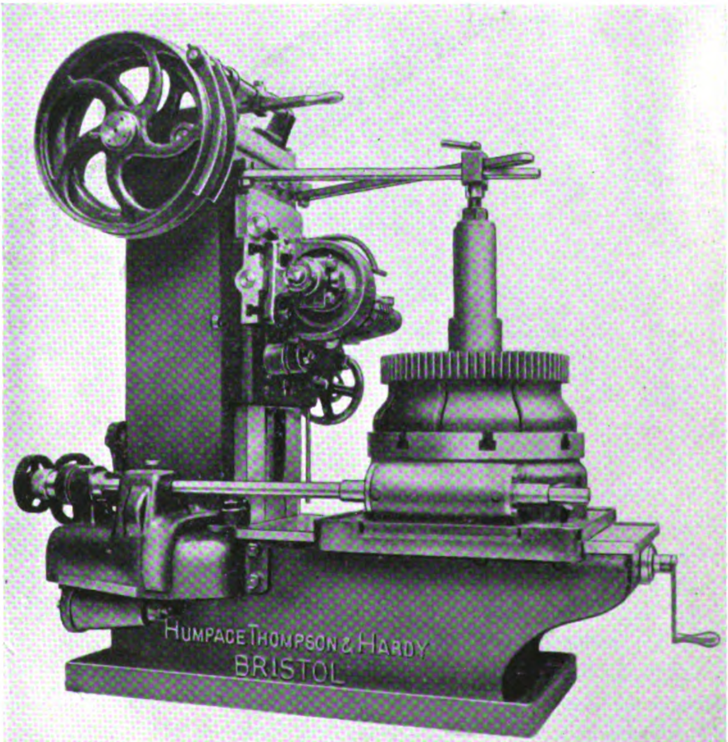

FIG. 14. SPUR GEAR HOBBING MACHINE. HUMPAGE, THOMPSON, & HARDY.

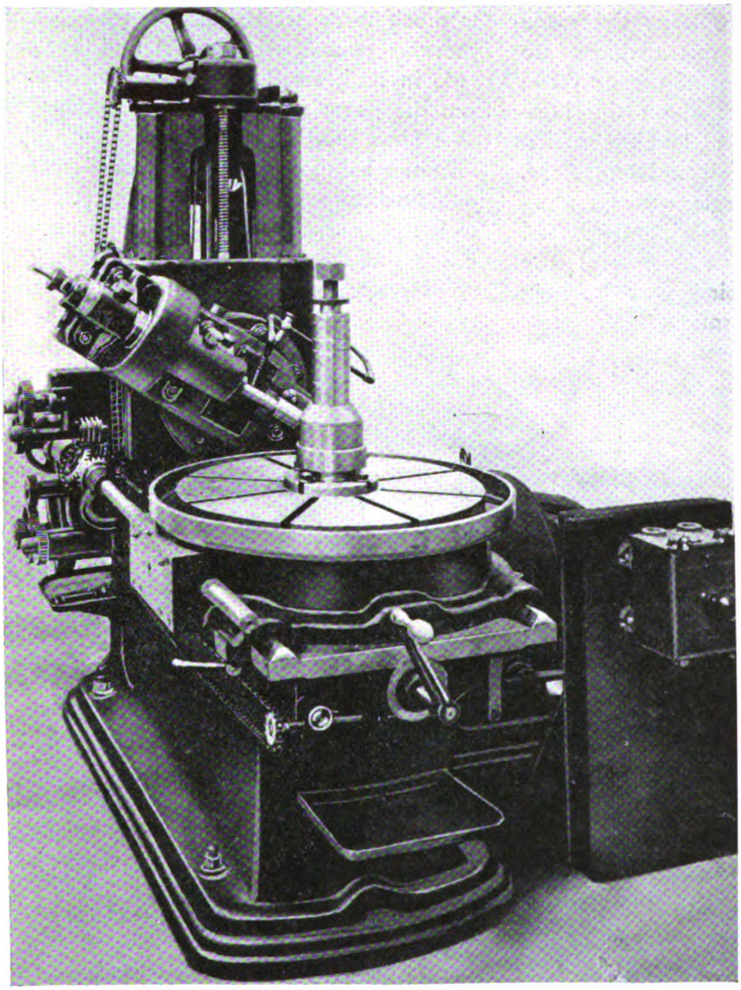

FIG. 15. AUTOMATIC GEAR HOBBING MACHINE. SCHUCHARDT & SCHUTTE.

gears. The Wüst gears are cut on machines which have cutters working on opposite sides, one producing the teeth of one half, the other the companion half of the wheel. The cutters are arranged to feed inwards in each case, so that one moves down while the other is feeding upwards.

As an instance of the increasing specialization in gear cutters may be mentioned the machine shown by Messrs. Brenot, Buronfosse & Cie., of Paris, at the Franco-British Exhibition last year. It was designed for cutting the teeth in sectors, or worm segments, which are employed in the steering gears of automobiles. It must be borne in mind that the sectors differ from other gears in not forming complete circles, so that provision has to be made for moving them a certain distance and then back again for another cut. In many cases the blanks are forged in one with their levers, but this does not interfere with the cutting.

The blank is placed on an arbor provided with a dividing worm wheel, turned by a worm which is controlled by change gears. The cutter, a spirally-fluted hob, is on a spindle connected to the change gears, so that the speeds of cutter and work are co-related suitably. Several cuts are necessary to finish a sector, and the mechanism is, therefore, so arranged that after the blank has turned the proper distance for the hob to commence the teeth, the sector is raised out of contact with the hob, and is given a rapid motion backwards, thus bringing the starting end again over the hob. The sector again descends and another cut is taken, this time a little deeper, and so on until the required depth is reached, when a stop comes into operation and prevents further feed, the attendant then removing the sector and putting in another blank. Sectors of different radii are accommodated by altering the vertical position of the arbor, which runs in a slide moving on a vertical bracket. The position of the cutter arbor remains unaltered. All the movements are automatic, being controlled by a system of dogs. Either right or left-handed teeth may be cut by the substitution of an intermediate gear in the change gear arrangements. It takes about half-an-hour to cut an average sector having a number of teeth representing 28 on the circumference, and a pitch of 10mm. in forged steel, and about a couple of minutes to take out the finished piece, put in another, and start the machine.

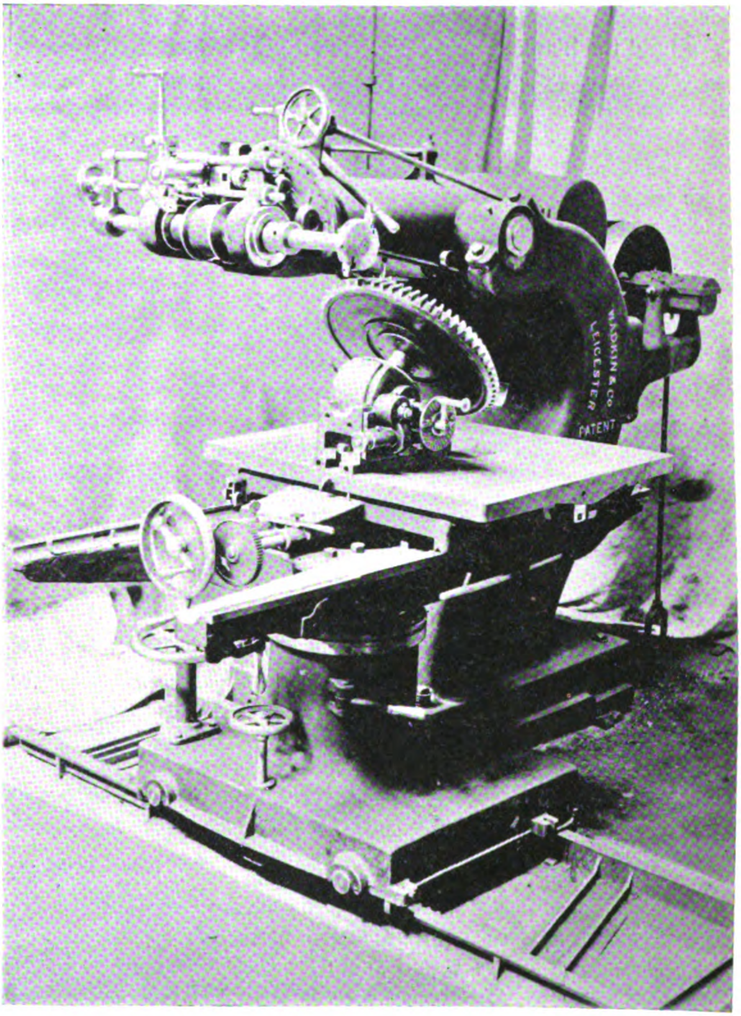

Fig. 16. Wadkin Woodworker Cutting the Teeth of a Bevel Wheel Pattern. The Bevel Wheel of 20in. radius is completed as shown in 50 minutes.

One of the features which distinguishes most recent machines from even their immediate prototypes lies in the provisions made for slogging. Gashing is essential in all gears above say about 2in. pitch, but more metal is removed per cut than formerly. The strains put on machines are therefore often very severe, with corresponding extra strains on the blanks, and spring is detrimental to accuracy. The designs and devices embodied to sustain these stresses and strains may be seen in many variations, and the result is spelt in greater output. Stiffening up of framings and outboard supports for mandrels are almost a matter of course, though flowing outlines often mask the strength. In some of the later Gould & Eberhardt automatic spur gear cutting machines using rotary cutters, a vice is provided for gripping the rim of the wheel blank, and in addition to the usual back stop which receives the pressure of the cut through the blank. The vice is carried on an adjustable arm at the front of the machine, which arm is set to bring the jaws into position to grip the rim of the blank. Moreover the action is automatic. The jaws are actuated by a screw which is so connected with the mechanism of the machine as to hold the blank securely during cutting, but releasing it while indexing is being done, and then clamping for the next cut.

Patterns for gears are being taken away from the bench hands and done on machines more extensively than ever. The latest machine is the Wadkin woodworker, a wonderful tool of universal application. It will not only perform all shaping of bends, cocks, and coreboxes, but will cut all kinds of pattern gears—spur, bevel, helical, spiral, and worm. A fly cutter is used, and the work is pitched by a dividing head like that used on a universal milling machine. A large wheel can be cut in about two hours.

❧

THE LOADE.

"The Loade above all other Stones hath this strange propertie
If sundry steeles thereto or needles ye apply
Such force and motion thence they draw, that they incline
To turne them to the Beare, which neere the Pole doth shine:
Nay, more, as many steeles as touch that virtuous stone
In strange and wondrous sort conspiring all in one
Together move themselves, and situate together:
As if one of those steeles at Rome be stir'd the other
The selfsame way will stirre though they farre distant bee,
And all through Nature's force and secret sympathie:

* * * * * * *

Would God men would be pleased to put this course in use
Their letters would arrive more speedy and more sure.
Nor Rivers would them stoppe, nor theeves them intercept.
Princes with their own hands their business might effect.
We scribes from blacke sea 'scaped at length with harty wils
At the table of the Loade would consecrate our Quils."

Hakewell's Apology, A.D. 1636.

SHIPBUILDING AND MARINE ENGINEERING.

It is almost unnecessary to add the words "marine engineering" to the title of any article dealing with modern shipbuilding, since the one connotes the other. When the one trade is active and progressive, so is the other, and *vice versa.* It is very much *vice versa* just now, for although shipbuilders and engineers thought that 1908 was about the worst year they had ever experienced, yet they have lived to see a worse one, though it is mending. How bad 1908 was people are realising better when they see how much worse 1909 is likely to be. The output of the United Kingdom in 1908 was 1325 vessels of 1,076,562 tons and 1,148,375 i.h.p., as compared with 1876 vessels of 1,828,295 tons and 1,775,705i.h.p. in 1907. Now a decline of three quarters of a million tons in the output of the shipyards is a thing that the man in the street may wonder at, but not understand. In broad terms, it means the consumption of about ten millions sterling less of material, and the non-employment of labour that might have earned a practically undefinable number of millions in wages. And the decrease is greater still this year.

The production of the Scottish shipbuilding yards and engineering shops in 1908 was 680 vessels of 400,194 tons and engines of 528,702i.h.p. In 1907 the total was 757 vessels, 675,173 tons, and 742,299i.h.p., so that in 1908 there was a reduction of 77 vessels, 274,979 tons, and 213,597i.h.p. The tonnage never before reached such a figure as that of 1907. It increased steadily from 1904, rising each year by nearly the same amount until at the end of 1907 the district had almost 620,000 tons. It was not expected that 1907 would improve on the figures of 1906, as all the indications then went to show that a period of dullness was inevitable. The contracts on hand, however, were larger than was generally known, and the yards were kept busy throughout 1907. The decline only took effect in 1908, and, very soon after the year began, labour troubles in the North East of England unsettled the whole industrial situation, while the prolonged stoppages of work in that district diverted a few contracts to the Clyde. The North East Coast and the Clyde, however, are now so closely bound together by organisations of employers and men that trouble in the one district immediately affects the other. When the employers and men on the Tyne, Wear, and Tees, were at variance builders on the Clyde were cautious in fixing dates for the delivery of vessels in fear of similar troubles, and the placing of contracts was thus deferred. Later, the general trade situation remained so bad that ship owners would only order new vessels at very low prices, and the work under construction on the river dwindled. At the end of the year the total was 569 vessels of 355,586 tons, as compared with 526 vessels of 619,919 tons in 1907. The number of vessels was larger, but this is accounted for by the building at Scotstoun by Yarrow & Co. of many barges and lighters for shipment. Of vessels for ordinary cargo and passenger services a much smaller number than usual were launched, while there were less than half a dozen that could be called high-class passenger liners. Large warships, too, were absent from last year's list of launches.

The shipbuilding and engineering returns from the English centres showed that with the exception of the Mersey district and the English Channel, the decrease was general.

	1908.			1909.		
	Vessels.	Tons.	I.H.P.	Vessels.	Tons.	I.H.P.
The Tyne	115	210,110	178,665	148	336,922	326,439
Tees and Hartlepools	38	96,061	68,489	33	240,268	118,100
The Wear	40	85,351	81,803	90	295,432	212,273
Royal Dockyards	5	43,060	—	3	51,800	—
Mersey to Solway	95	39,232	68,835	117	20,645	66,765
The Humber	98	21,714	27,720	135	36,659	55,730
English Channel	106	10,237	66,504	124	9,499	52,151
The Thames	112	9,881	23,723	270	15,420	109,465
Bristol Channel	14	2,106	443	61	8,025	253
	623	517,752	514,183	1,031	1,014,670	951,176

It represented over 400 vessels, 496,000 tons, and 436,000i.h.p. more than the work of any three of the English districts for the year. The North East Coast of England suffered most. The Tyne fell from 336,000 tons to 210,000, the Tees and Hartlepool from 240,000 to 96,000, and the Wear from 295,000 to 85,000. The Mersey district total was higher because of the launching at Birkenhead of a large dredger for the Mersey Docks and Harbour Board, as well as of a large tonnage of barges; and that of the English Channel because of the launching at Southampton and Cowes of a number of torpedo boat destroyers. The decrease on the Thames was not accounted for by bad trade, but by the removal of old-established yards to other localities. The above table summarises the work of the English districts.

The Belfast shipyards seem to be always able to compete and even sometimes to obtain work when England and Scotland are idle. All through 1908 they were busy and they had a total of sixteen vessels of 156,831 tons as compared with thirty-two vessels of 137,360 tons in 1907. Messrs. Harland & Wolff launched the Holland-Amerika liner *Rotterdam*, the Red Star liner *Lapland*, and the "combination" White Star liner *Laurentic*. The year 1909 began favourably there with two big White Star liners and vessels in hand for the Bibby, Royal Mail, Australian United, Leyland, and other lines.

The Clyde last year retained its place as leading shipbuilding centre of the world. Its total in 1908 was very much lower than that of 1907, but still larger than that of either Germany or the United States, while the output of the North East of England districts was so low that their highest—that of the Tyne—was 145,000 tons behind the Clyde. By grouping the three districts a tonnage larger than that of the Clyde may be obtained, but it is hardly fair to set one river against three. The Tyne, the Wear, and the Tees and Hartlepool are usually in the first half-dozen centres in the matter of tonnage. The following was the order of the first nine shipbuilding firms in 1908 :—

—	Vessels.	Tons.
Harland & Wolff	8	106,528
American Shipbuilding Company (7 yds.)	22	103,246
Swan, Hunter, and Wigham Richardson	17	60,266
Workman, Clark, & Co.	8	50,303
Armstrong, Whitworth & Co.	9	51,384
Russell & Co	13	48,619
The Vulcan Company	10	47,030
The Great Lakes Company	10	46,952
The Weser Company	3	39,100

Apart from the great decrease in production there is no very outstanding feature in the shipbuilding trade of the world. The grand total decreased from 3495 vessels of 3,301,597 tons and 3,145,851i.h.p. in 1907, to 2876 vessels of 2,268,763i.h.p. in 1908. There was a falling off in the world's output to the extent of 619 vessels, —1,032,834 tons and 999,692i.h.p. But 1908 and 1907 were abnormal years, and comparisons with them are not altogether fair. The depression in trade has been felt more severely in British shipyards than in those of foreign countries. The decrease in the United Kingdom last year amounted to over 750,000 tons, while in other countries it was about 280,000 tons. This is in Board of Trade tons gross for Great Britain and British Colonies, and the equivalent measurements in other countries as used by the Registry Societies. War vessels are in all cases "displacement tons." Displacement, though it gives larger figures than the "gross" measurement would, does not represent the comparative value of a warship or of the work required in building one vessel.

The figures, however, are puzzling, as the shipbuilding returns never agree with those of Lloyd's or with the estimates of Labour and other societies. Each vessel has four tonnages, but none of them applies to the tons of steel and iron used in construction. The standard official tonnages are:—Lloyd's gross tonnage, Lloyd's net tonnage, tons deadweight, and tons displacement. The Boilermakers' Society reports refer to tons deadweight, while the Admiralty adopt tons displacement. The steelmaker gets only the actual tons of material that are used in the construction of the ships. A comparison of high-class cargo steamers by an expert is as follows:—

Displacement ..	16,000 tons.	Admiralty.
Deadweight	10,400 tons.	Boilermakers' Society.
Lloyd's gross tons ..	7,600 tons.	Lloyd's Register.
Steel and iron ..	4,500 tons.	Material.

The steelmakers' total is less than one-half the deadweight tons and two-thirds of the register tons. Another type of cargo vessel is thus analysed:—

Displacement	11,500 tons.
Deadweight	8,200 tons.
Gross tons	5,000 tons.
Material	2,500 tons.

In this case the steelmaker gets half the register tonnage, but less than one-third of the deadweight tons. By separating tons from tonnage it is thus possible to arrive at a fair estimate of the actual work that is to be done, and at figures that correspond more nearly with the real output.

The depression in the shipbuilding trade has affected seriously the steel and iron industries, and also to some extent the output of coal. With a number of yards practically idle and the large majority working at less than their average capacity, there could not be the same demand for materials as in a busy year. The dullness is by no means confined to any one district, and reports from the Continent all show that the leading firms have had to exercise the greatest care in order to conserve their financial stability. Many have had to pass their dividends, while others have paid much less than in previous years, particularly in Germany, which is supposed to be Britain's strongest competitor in shipbuilding. It might have been better for the industry if less capital had been put into it and less done to keep the yards open at any price, as builders have been producing tonnage for which no profitable employment could be found. Speculation in providing unnecessary ships has staved off the revival in trade. It, however, prevented the Clyde from feeling the depression so severely as the Wear and the Tees. It kept the cargo-building yards with very few vessels on hand, while the larger firms obtained some contracts. The hope now is that the worst of the depression is past, and that by the time the naval vessels now on order are launched not only will there be more warships to build, but there will be such an improvement in shipping as will create a demand for many new merchant steamers.

There was recently a general belief that within the present year the shipbuilding and marine engineering trades would experience that revival for which all have been waiting and watching. There is practically nothing as yet to justify the expectation apart from the impression that the reaction is now due. Natural wastage has affected the shipyards very little, and but for the recent placing of warship orders the yards would have been little busier than they were at the depth of the depression.

Even in the large yards which have obtained naval contracts short time is still the rule. The vessels under contract on the Clyde in the beginning of 1909 consisted of one cruiser of about 4500 tons displacement at each of the Fairfield, Clydebank, and Dalmuir yards, three destroyers at Fairfield, three at Clydebank, one at the London and Glasgow Company, Govan, and one at Messrs. Denny's, of Dumbarton. This makes a total of only about 21,000 tons displacement, but it represents a national expenditure of some £1,700,000. This, with machinery orders placed during the year, means that the district had received up to January 1 £2,500,000 worth of the naval work that was then available. Besides the cruisers and destroyers Messrs. John Brown & Co. supply the turbines for the battleship *Neptune*, which is building at Portsmouth Dockyard, and for the cruiser *Indefatigable*, building at Devonport, and the Fairfield Company supply turbines for a cruiser building at Pembroke. This work does not mean so much as it seems so far as providing employment in the shipyards is concerned. A large proportion of the money is spent outside the shipbuilding districts in armour, armaments, and the many "parts" which, although they require material of the highest quality, do not call for steel in large quantities, or of the specifications which employ large numbers of men in the steel works.

Naval shipbuilding was never so interesting as it has been since 1908. The capital ships of last year—the British *Bellerophon*, German *Posen*, the British *Invincible*, German *Blucher*, present different solutions of the same problem. The *Dreadnought* is the scientific embodiment of the battleship, and the *Bellerophon* is the logical development of it. The problem is not to get speed alone, but to combine in a ship of reasonable dimensions great destructive power at long ranges, protection against all the ascertained dangers of naval warfare, large fuel capacity, and speed. If the design is deficient in one of these, the remaining qualities are necessarily affected.

The *Invincible* and her sister ships are improved cruisers, but among cruisers there is much confusion of types.

Vessels of the *Boadicea* type are fast enough for scouting, but their armament and coal capacity are those of cruisers. The "scout" problem is worked out further in the torpedo boat destroyer. The interesting point of destroyer development is that we have in course of construction the 36-knot *Swift*, the 33-knot boats, of which the *Afridi*, the *Saracen* and the *Maori* are examples, and the 27-knot vessels of the 1908 programme. The *Swift* is an experimental boat of 1800 tons displacement and 30,000h.p.; with steam turbines and oil fuel she is the highest development of this type of naval architecture. She is a destroyer with a protected cruiser's sea-going qualities. The 33-knot vessels under construction are essentially destroyers. The announcement that the 27-knot vessels are to burn coal instead of oil has been misunderstood. These protected vessels are in respect of everything, except fuel, the embodiment of the lessons learned from the earlier boats. Our development of the submarine is in the direction of increased radius of action, involving greater dimensions and other qualities. A perfect oil engine is the thing most desired in this department. The recent Russian submarines have Gardner engines.

The output of the British Dockyards during 1908 was as follows :—

Vessel.	Type.	Tons.	Built at
St. Vincent.. ..	Battleship.	19,250	Portsmouth.
Collingwood ..	Battleship.	19,250	Devonport.
Boadicea	Scout.	3,300	Pembroke.
C17	Submarine.	630	Chatham.
C18	Submarine.	630	Chatham.

With such a large reduction in the work done in 1908 in the country's shipyards, it was of course inevitable that there should be a decrease in the production of the marine engineering shops. Last year's work represents on the Clyde a total of 474,400i.h.p., as compared with 668,527 in 1907—a reduction of 194,127i.h.p. There was less demand for machinery generally, and in consequence less work for engines of standard types, and there were remarkably few large or highly powered vessels built on the river. In 1907 there were the turbines for the battleship-cruisers *Indomitable* and *Inflexible*, for the Mediterranean steamers *Cairo* and *Heliopolis*, and for five turbine steamers at Dumbarton, as well as reciprocating engines for an exceptionally large number of cargo steamers. In 1908 there was only the machinery for three Orient liners, the P. & O. liner *Malwa*, the turbines for three destroyers at Dumbarton and for the cruiser scout *Boadicea* at Clydebank.

In 1907 the Fairfield Company had the largest output of machinery on the Clyde — 112,000i.h.p. In 1908 Messrs. Denny & Co. headed the list with 57,100, Messrs. John Brown & Co. were second in 1907 with 73,000, and they were third with 41,760i.h.p. in 1908. Messrs. Yarrow's work does not show very high in tonnage records, but it is work for which the highest skill and the greatest experience are required.

The lack of demand for cargo steamers and the consequent dullness on the Tyne, Wear, and Tees, accounts for the reduction in the work of the North Eastern Marine Engineering Company and their retiral from the place they had in 1907 as builders of the largest horse power of marine engines. The Fairfield Company, who had in 1907 the turbines for the *Indomitable*, the *Heliopolis*, and the *Cairo*, were then second, and the Vulcan Company of Stettin were third. In 1908 the Vulcan Company was first, the North Eastern Marine Company second, and Messrs. Harland & Wolff third.

The following were the largest producers of marine engines in 1908.

	I.H.P.
The Vulcan Shipbuilding Company	116,930
North-Eastern Marine Company (2 shops) ..	67,680
Harland & Wolff	65,840
Vickers, Sons, & Maxim..	58,850
Denny & Co.	57,100
Cie. Electro-Mecanique	51,200
David Rowan & Co.	43,890
John Brown & Co.	41,750

The leading merchant vessels of the year must be taken from a dozen of over 10,000 tons. The Norddeutscher Lloyd's *George Washington*, built at Stettin, was the largest, but she was run close by the Rotterdam Lloyd steamer *Rotterdam*, built at Belfast. Messrs. Harland & Wolff launched five vessels, the smallest of which was over 14,000 tons. No merchant vessel of over 10,000 tons was built during the year outside of Great Britain and Germany. The following were the largest products :—

Vessel.	Tons.	Builders of Vessel.
George Washington.. ..	23,500	The Vulcan Company.
Rotterdam	23,980	Harland & Wolff.
Berlin	19,200	The Weser Company.
Lapland	18,565	Harland & Wolff.
Cleveland	16,500	Blohm & Vass.
Laurentic	15,340	Harland & Wolff.
Megantic	15,340	Harland & Wolff.
Minnewaska	14,342	Harland & Wolff.
Orsova	12,000	John Brown & Co.
Otway	12,000	The Fairfield Shipbuilding Co.
Orcoma..	11,533	William Beardmore & Co.
Malwa	10,881	Caird & Company.

Merchant steamers larger than the big Cunarders have been laid down at Belfast, and battleships heavier and more powerful than the *Dreadnought* are under construction in Great Britain. So far as naval architecture is concerned, the developments reqresented by these vessels are following naturally on the increase of size in the one case and on the rearrangement of armament in the other. For radical change in design we must turn to the tramp steamer. Several vessels on the *Isherwood* principle of construction were launched during 1908, and the system is being adopted for certain trades. The most important development last year was the combination of the reciprocating engine and the steam turbine in marine engineering. Messrs. Denny of Dumbarton were the first to apply the turbine to the propulsion of merchant steamers, and they were also the first to demonstrate the practicability of Mr. Parsons' proposal that for low-speed vessels the old engine should be retained as an auxiliary to the turbine. The New Zealand steamer *Otaki* proved on trial more economical of steam than her sister ships. Messrs. Harland & Wolff completed the *Laurentic* for the White Star Line's new Canadian service on the combination system. The turbine has been proved highly successful for high speeds, but engineers are now waiting for the reversing turbine and the adaptation of the fast-running turbine to the slow-moving propeller.

Mr. H. A. Mavor and Mr. W. P. Durtnall have each submitted definite proposals for getting over the difficulties by introducing electric control between the turbine and the propeller.* In neither case has anything yet been done in the way of practical experiment, but if the system can be shown to be satisfactory in such matters as space and cost of installation and of running, it will be tried on a sea-going vessel. If successful, it will be more revolutionary than the combination of turbines and reciprocating engines, but it will not abolish the steam generator. For this we must look to the oil or gas engine. The Royal Naval Reserve gunboat *Rattler* has proved that gas engines may be used for a vessel of fairly large size.

It is comforting to know that as we reach the end of the first half of the present year there are indications of improvement in both shipbuilding and engineering. The improvement may be more in the distance than in the pay office, but it is in sight. It is true that in the greater portion of the past half-year none of the yards has been fully employed, and some of them have been practically idle, for even repair work was comparatively scarce when so many vessels were laid up altogether. This told heavily, of course, on the engine shops, and the ranks of the unemployed have been swollen by large numbers of engineers and other highly skilled artisans. The output of the shipyards in the half-year will not, however, be much, if at all behind that of the first half of last year, because a number of vessels have been put into the water this year that in ordinary circumstances would have been launched in 1908, but were held back on owner's request because of the dullness of the freight markets. But while shipbuilders have had no labour troubles this year—alike in the shipyards and the engine shops the new working agreements are operating splendidly—yet they have been hampered by dear material. There is no doubt that until now steel has been too dear in relation to the general state of trade and to the conditions of the shipbuilding industry. But it has been held up by the combines of the North of England and of Scotch steel manufacturers acting together in unison. They so held up ship plates and angles that shipbuilders could not pay and live, although the makers were willing to sell to exporters at 10s. or 20s. per ton below what they would sell at to home consumers. This state of affairs has caused much dissatisfaction in the shipbuilding trade, and it brought into the market a good many bear sellers who anticipated a fall in steel, and were prepared to cover their sales in Wales, or in Germany or America, if local steel makers did not come down; but they have come down, and now prices are nearer a level on which shipbuilders can operate. As it is they have been booking a good many contracts during the last three months, and the second half of the shipbuilding year opens with a much rosier prospect than did the first half-year. It is noteworthy that most of the orders for cargo steamers that have been placed of late are for deferred delivery. The owners do not want them until the freight markets show some sign of improvement, so that while some shipbuilders may have their order books comfortably filled they have not their yards active.

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* A fully illustrated account of these systems appeared in THE ELECTRICAL MAGAZINE AND ENGINEERING MONTHLY April and May, 1909.

In the circumstances the Naval Programme never had greater importance, and if the rigid economists who denounce the expenditure on *Dreadnoughts* would only consider the industrial issues they might be less rigid. It is, as the present writer has said elsewhere, quite a mistake to suppose that all expenditure on armaments is waste. On the contrary, in the case of naval armaments the expenditure is highly beneficial to many of our most important industries.

The fact is that the shipbuilding industry is the largest consumer of iron and steel in this country, and the iron trade is the largest consumer of coal in the world. In the coal, iron, and other industries allied with shipbuilding and shipping, by far the larger portion of our working population are engaged, and these are the largest consumers of our textile industries, of our agricultural industries, and of our imports of food products. Thus activity in shipbuilding does not mean merely activity in the shipbuilding districts. It means active industry all over the country. A shipbuilding firm on the Thames, let us say, may get its plates from Sheffield, its anchors and chains from Leeds, its engines from the Tyne, its steering gear and auxiliary machinery from the Clyde, and its miscellaneous material from various other districts. No one district produces all the elements of a first-class modern steamer. In the case of warships, the area of industrial distribution is even greater, for then calls are made for steel armour, for guns and gun-mountings, and for the appliances incidental to armament—all the products of special and entirely separate machinery, in the production of which an enormous capital is invested.

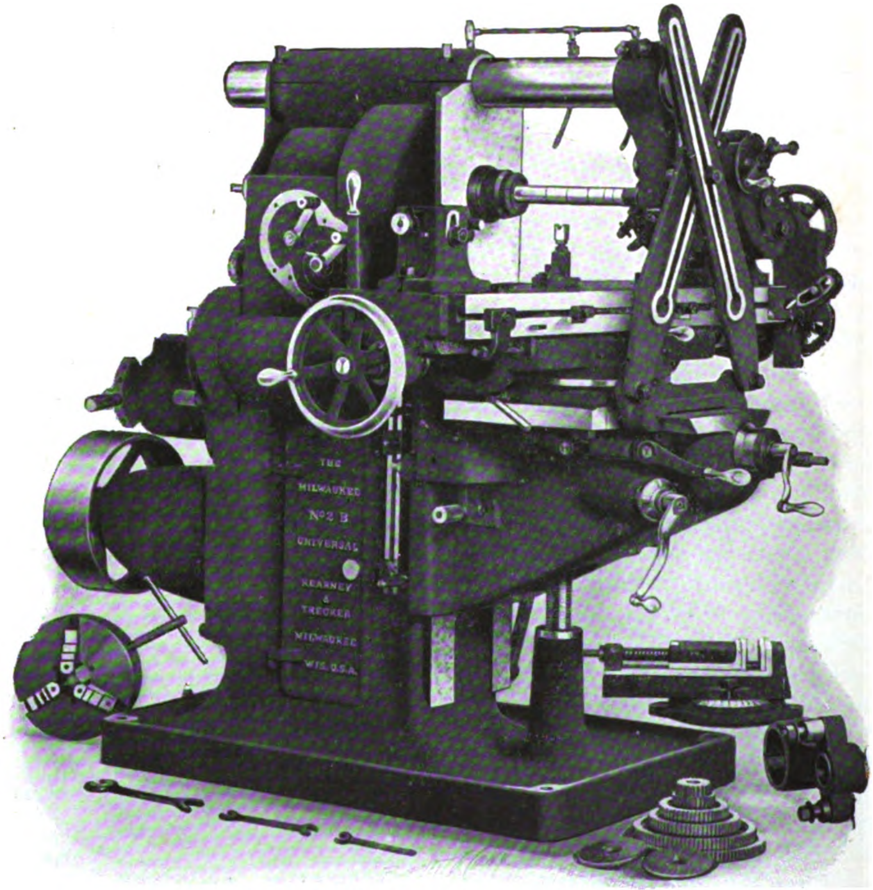
It is, then, a matter of great industrial importance that when shipbuilding is depressed in respect of mercantile tonnage it should receive employment in the production of warships. We would, as tax-payers, rather avoid the expense of warship-building, but as industrial producers we are interested not only in the maintenance of the strength of the navy, but also in the industrial production of warships. It is true that only a comparatively few yards in a few of the shipbuilding districts are equipped for the production of warships, but these yards, in themselves a national asset, form the centre of an invaluable industrial population, including the best technical skill in the world.

The naval work which tends to the activity of the shipyards and engine shops throughout the country, and through them to the iron and steel works and coal mines, also tends to the increased employment of merchant shipping as carriers. It is better that the naval construction work should be allotted to contractors in different parts of the country than concentrated in the dockyards. Whatever money has to be spent on the building of warships, the more widely the spending of it is distributed over the shipbuilding districts of the country, the better for the industries of the country. And it is essential to the country that the private yards capable of building warships should be kept supplied with orders so that they may be maintained in a constant state of efficiency.

No Government establishment can turn

out the guns and armour and machinery required for a warship, but three or four private establishments can turn out the whole outfit and place on the waters a complete battleship ready for action. Several of our private yards can build the hulls and also construct the machinery, whereas the dockyards can build the hulls only. As our shipping is our greatest Imperial industry, so are the shipyards and engine shops equipped for warship work our most valuable national assets. They ought to be encouraged and kept so well prepared that they can turn out any number of *Dreadnoughts*, or their successors, in the smallest possible time. The distribution of Admiralty orders is especially desirable when merchant shipbuilding is dull.

BENJAMIN TAYLOR.



MILWAUKEE UNIVERSAL MILLING MACHINE.

The modern tendency to simplify milling machines by reducing the number of belts required is shown here. No counter shaft is used, the line shaft being directly connected with the machine by a single belt. The pulley runs continuously, the machine being started or stopped by lever. The lubrication is by a double pump, one side serving for the machine parts, the other for the lubrication of the cutter. The machine is of American manufacture, C. W. Burton, Griffiths & Co. being the agents for its sale in this country.

ELECTRO-HYDRAULIC RIVETER.

THERE are certain processes in engineering manufacture which are essentially suited to the peculiar merits of hydraulic power, and to which neither the electric motor nor any other engine can be applied direct with profit or convenience. In the case of riveting machines, for example, the hydraulic ram is unapproachable for speedy and effective working. For portable work hydraulic transmission has strict limitations, and it is in this respect that the electric motor is unassailable. It is, therefore, after all, reasonable that the particular merits of the hydraulic and electric systems should be combined where portable riveting machines require to be perfected. The illustrations herewith show examples of this type of machine introduced by the Maschinenfabrik Oerlikon as one of the most recent additions to their widely diverse range of engineering specialities.

It may be thought at first sight that machines of this type must be more or less complicated and difficult to handle and control as portable tools, or that the efficiency and speed of working are likely to be of doubtful value. Naturally the electro-hydraulic combination is heavier than the all-hydraulic riveter, but its weight is not prohibitive; the smaller machine shown in Figs. 1 and 2 weighs about 2750lb., and on

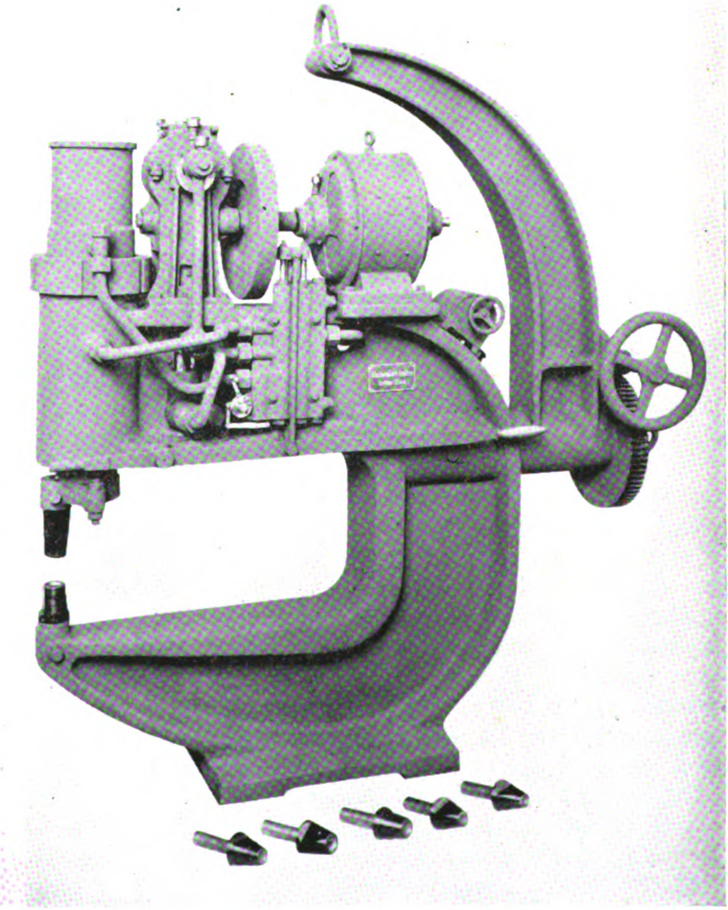


FIG. 1. PORTABLE ELECTRO-HYDRAULIC RIVETER.

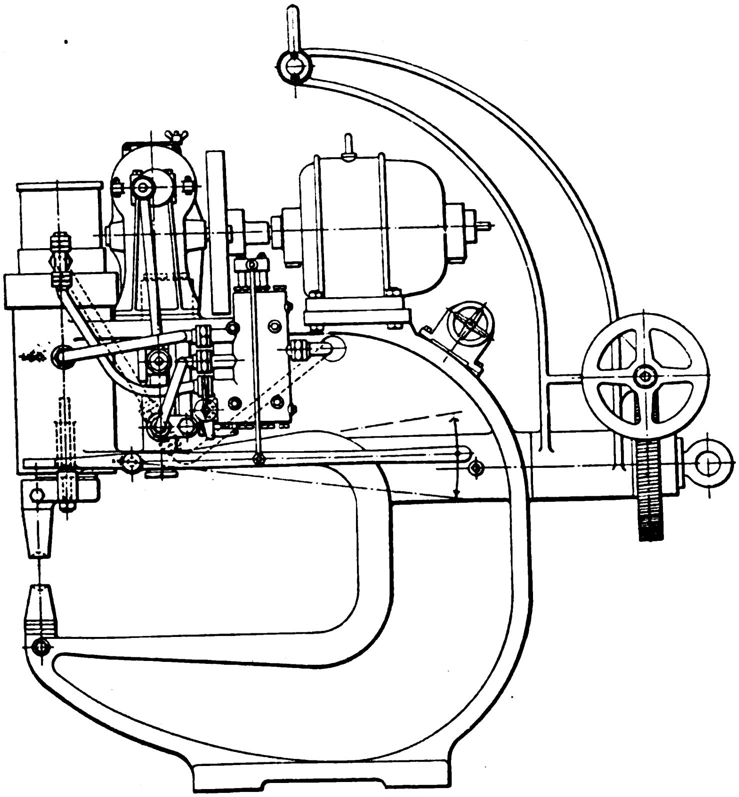


Fig. 2. Details of Portable Electro-Hydraulic Riveter.

test with three operatives puts in 1000 three-quarter inch rivets during a ten-hour day, the quality of the work being of the highest class.

As will be seen from the illustrations, the machine is of a very compact and rigid design; that shown in Figs. 1 and 2 consists of a well-proportioned steel casting having a gap of 30in. and a width of 16in. The machine can be slung for either vertical or horizontal work, and set to any angle. The arrangement of the electric motor and driving gear is clearly shown on the drawing; the motor, of four to six horse-power, runs at a speed of 1420r.p.m., and drives the pump through an enclosed worm gear and a pair of connecting rods. The pump is of the differential piston type, having brass-bushed cylinders, and acting at about 170 1½in. strokes per minute, this giving an equivalent circulation of about two gallons per minute. The liquid used is a mixture of water with 40 per cent. to 45 per cent. of glycerine, which renders the machine frost-proof, so that it can be used in the coldest weather in open yards without fear of the liquid freezing and bursting the machine. The hydraulic cylinder of the upper snap is cast on the main frame; it is designed for a maximum riveting pressure of 90,000lb., and to deal with rivets up to ⅞in. in diameter. The piston is 6.3in. in diameter, and has a stroke of 2¾in. Details of the cylinder and the valve controlling gear are shown in Figs. 4 to 8. The piston has ring packing and external guides (Fig. 4), its acting stroke speed is 16½in. per minute, the return speed being 70in. per minute. The return stroke is made by the hydraulic pressure acting in the annular space below the piston.

Reference to the illustrations, Figs. 4 and 6, will explain the hydraulic control of the machine. With the hand lever in the central position as shown, the ram is at rest and the water circulates round the stems of the two valves and through the nipple C to the reservoir. Moving the hand lever downwards causes the liquid to enter at B, pass round the first valve stem and through D on to the cylinder by pipe E; thus the ram descends under pressure and the water under the piston exhausts by way of F into the valve chest at G and away to the reservoir by means of the upper transverse port and nipple C. Whilst the lever is in the lower position the downward pressure is maintained on the ram, the full pressure being held even after the ram has come to rest. The maximum pressure thus available can be set to suit the particular work in hand by adjustment of the spring-controlled valve H. Under maximum-pressure conditions with the ram at rest the water raises the valve H and passes to C.

The ram is raised by moving the hand-lever to the upper position. The water under pressure enters at B, passes out at G, and enters under the ram at F. The water above the ram escapes by E to the reservoir by way of D, the lower port and C. It will be noticed that the upper snap is set eccentrically on the ram, this permitting the machine to work on rivets in corners or close to flanges.

The motor starter and switch are mounted on the side of the machine, and the motor once started runs continuously at a constant speed, the only control demanded of the operator being the simple movements of the hydraulic hand-lever as above described. Tests show that the hydraulic pressure in the cylinder is fairly constant over the stroke, it being almost perfectly constant during the actual squeezing of the closed rivet, the maximum pressure in the cylinder being about 3400lb. to the square inch.

The Oerlikon Works also build riveters on the principle of the above described system of a very much bigger and heavier calibre. Fig. 3 illustrates, for instance, a machine for the tube and boiler industry. It embodies an essential feature for this large type of machine, viz., that of a sheet closer arranged concentrically with the snap.

A number of curves illustrating several phases of the performance of the smaller machine are given in Fig. 9. Curve I. is the percentage of the theoretical piston speed obtained at various working pressures, the falling off being due to the inevitable slight slip past the valves and C. Curve II. gives the relationship between the revolutions of the motor and the pressure; Curve III., the amperes taken by the three-phase motor at 50 cycles and 240 volts; Curve IV., the efficiency of the motor at various loads; Curve V., the power factor of the motor at various loads; Curve VI., the output of the motor in brake horse-power for various closing pressures; Curve VII., the

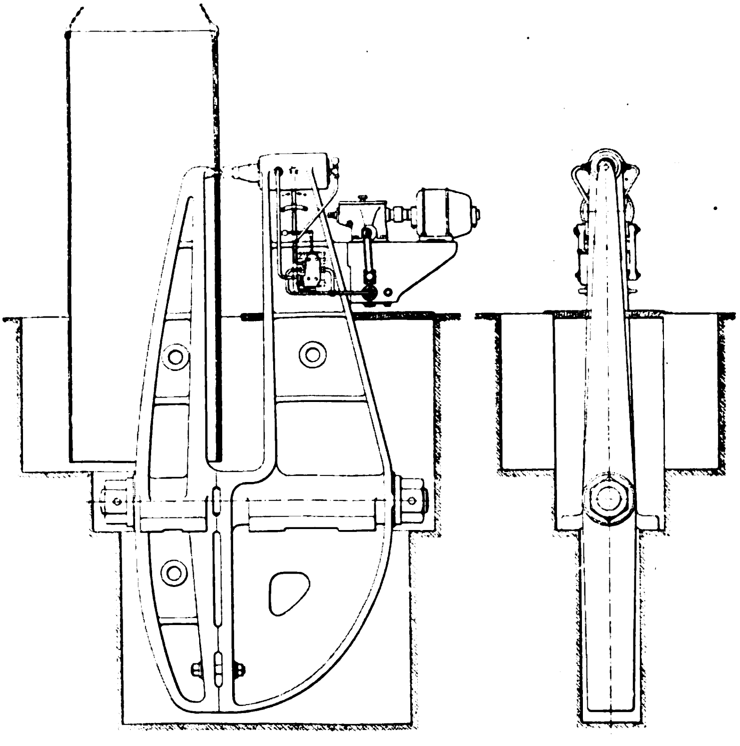


Fig. 3. Large Size Electro-Hydraulic Riveter.

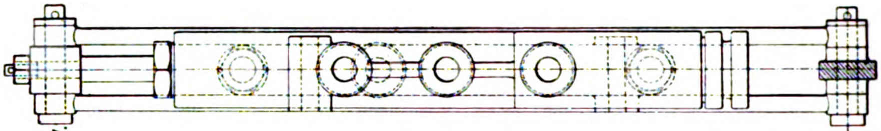


Fig. 7.

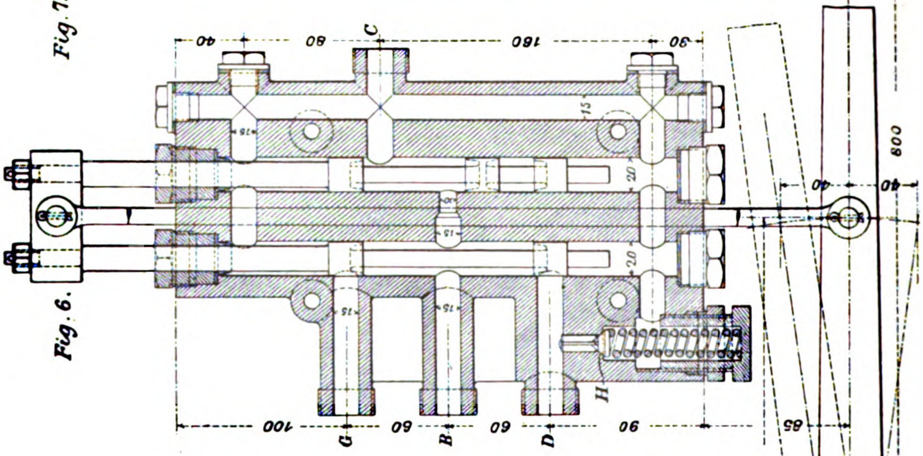


Fig. 6.

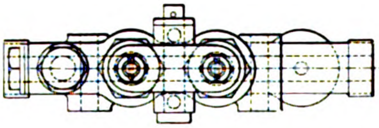
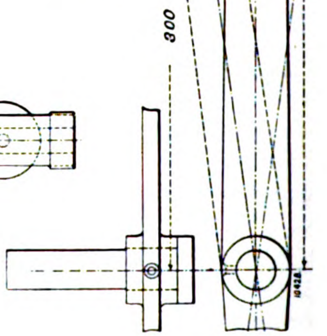


Fig. 8.
PLAN



Cylinder Details of Portable Electro-Hydraulic Riveter.

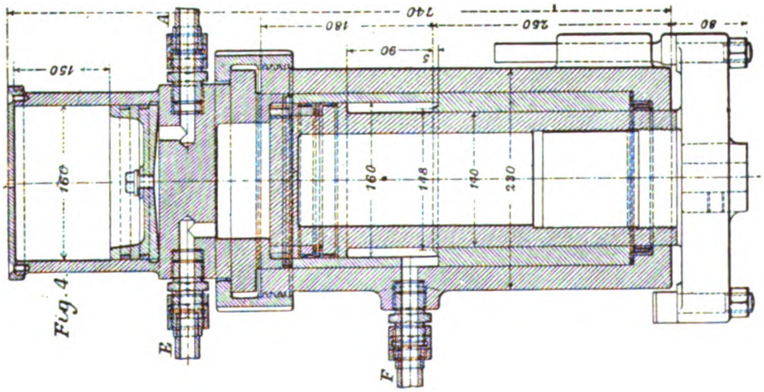


Fig. 4.

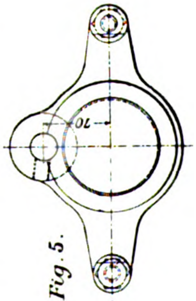


Fig. 5.

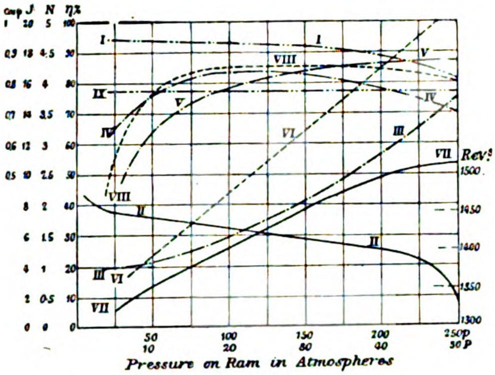


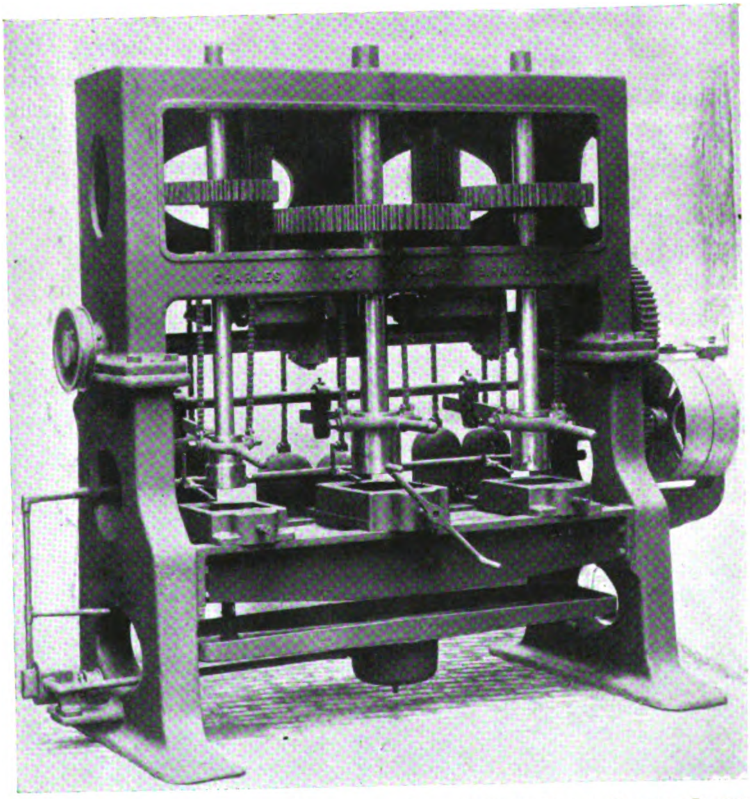
Fig. 9.

effective work in horse-power done by the machine; Curve VIII., the efficiency of the worm-gear; and Curve IX., the losses due to friction of the water. The vertical scale marked J represents amperes, and that marked N is horse-power.

That there is likely to be very considerable scope for machines of this type is certain. Whilst its weight is naturally somewhat greater than that of the all-hydraulic tools, it affords the greater degree of flexibility and simplicity in operation.

Mr. G. Wüthrich, Oswaldestre House, Norfolk Street, London, W.C., as manager and chief engineer, has charge of the Oerlikon interests for this country and the Colonies.

* * *



Large Three-spindle Tapping Machine by Chas. Winn & Co. for Tapping Sockets and Flanges up to 6in. Gas.

THE PARIS METROPOLITAN RAILWAY.

WHEN the entire project for the subway is completed, Paris will be undoubtedly the best equipped of the European capitals as regards underground electric railway lines. Starting in 1900, when the first of the subway sections running directly across the city, from east to west, was opened up, the number of lines in various parts of the city has been gradually increased up to the present year, and the construction of newer sections of the general project is being pushed forward actively. As regards the sections of subway which are wholly finished and running for service, there are no less than twenty-three miles in operation at the present time. From the start the Metropolitan lines were well patronised by the public, as Paris had been suffering for a long time past from insufficient means of communication between different parts of the town. The Metropolitan subway therefore proved to be a great boon to the public, and all the different sections of the line are carrying a heavy traffic.

The greater portion of the subway lines included in the first part of the project voted by the Municipal Council several years ago are open for service, or are rapidly being finished. Outside the regular Metropolitan system there is now being constructed what is known as the North-South subway section. Although the electric trains and the general disposition of the tunnel of this section will conform to the standard of the former subway, from an operating standpoint the North-South line has been made distinct from the regular system; and this was done mainly for the purpose of having it built with greater expedition. The initial project comprised eight different sections of line. Quite recently, however, the Municipal Council decided upon the construction of a further new series of lines, including not less than ten different sections, so as to complete the subway system, and afford the transportation facilities which are still sorely needed in some quarters of the town. Together with the former lines, the total length of the subway system when completed according to the present plans will be about

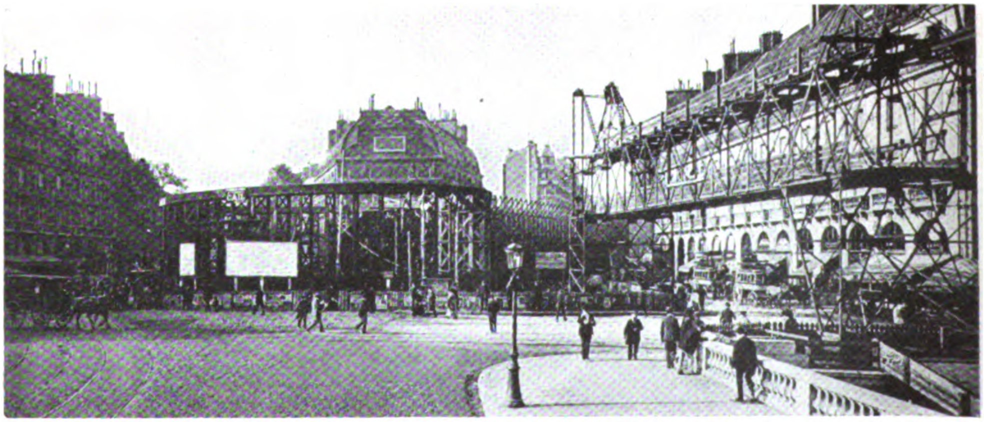


FIG. I. THE SAINT-MICHEL STATION UNDER CONSTRUCTION.

seventy miles, so that it will be seen that as a whole the Paris Metropolitan will be one having a vast scope. The former plans include among others a belt line which passes around the city, but as this route is somewhat in the outlying quarters, it was decided in the new project to build a second belt line which will pass by the Boulevards and the Invalides, crossing the Seine twice upon its course, passing also under the Boulevard St. Germain. This will be one of the most interesting of the new lines, as it will be in the heart of the city over its entire course, and it will no doubt carry the heaviest traffic of any of the sections.

Regarding the standard construction which is adopted on the Paris system, it will be remembered that it consists, for the underground portions, of a double-track electric line running in a tunnel of a general elliptical section. The subway stations are of a larger elliptical section, and have a station platform at each side of the double track line, these platforms being of concrete and lying flush with the level of the car floor. The stations are lined throughout with a white glazed brick which gives them a clean and attractive appearance. Staircases leading from the street level give ready access to the station platforms, the only disadvantage being that some of the tunnels lie at a considerable depth, especially where two lines cross, one above the other, so that there are a larger number of stairs to climb at the station. However, steps are being taken to install electric elevators in some of the deeper stations. Rolling inclined foot-paths or platforms are also to be adopted for the station approaches. Both these systems are on trial in stations which have been selected for the purpose. Where two, or even three, of the tunnels cross at one point, extensive underground work had to be carried out for the different stations and the transfer galleries which pass from one station to the other.

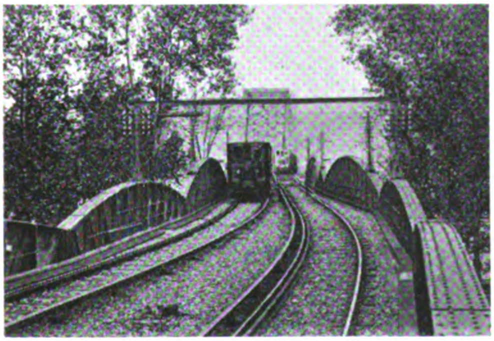


FIG. 2. PART OF OVERHEAD LINE.

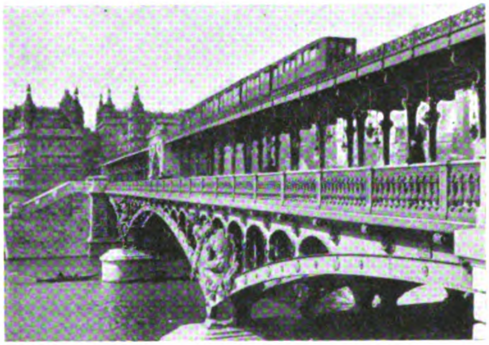


FIG. 3. TRAIN ON THE PASSY BRIDGE.

The standard train of the Metropolitan system uses a type of motor car working on a 500-volt third rail and mounted on double bogies. The motor cars have an end cabin for the controlling apparatus, while the rest of the car is taken up with seats as in the regular passenger cars. The motor and passenger cars are similar in general appearance, and the trains are made up of a motor car at each end, with from three to five passenger cars in the middle.

While the first section of the Metropolitan to be constructed, running parallel to the Seine, is built entirely in tunnel, this is not so in the case of most of the succeeding sections. Owing to the great differences in level in various parts of the town, a tunnel could not always be used without running the profile of the line at too great a depth. Accordingly we find that many parts of the line are run on elevated structures in various quarters of the town. Thus the northern half of the belt-line runs for part of its course, starting from

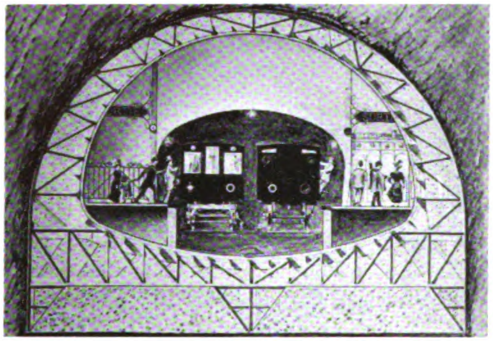


FIG. 4. MIDDLE CAISSON OF STATION.

the Place de l'Etoile, in tunnel, and then comes out upon an elevated structure, continuing upon the latter for a considerable distance. The same is true for the southern half of the belt-line, and in the lower ground near the Seine it is carried on an overhead structure. In this way the trains repeatedly come out of the tunnel and mount upon the elevated portion, then descend again into the tunnel. The overhead portion is made up in general of iron bridge trusses of a standard length of 70ft., mounted upon stone pillars. Some of the trusses, however, reach 150ft. in exceptional cases where the line runs over a wide street crossing. Some of the illustrations give an idea of the various types of overhead construction which are employed. The two overhead portions of the south line are 8316ft. and 2871ft. in length respectively, and figure for over one-third of the total length of this section. On this portion there are employed fifty-five bridge trusses of standard 70ft. length, and thirty-eight trusses varying from 66ft. to 90ft. length.

The Metropolitan lines cross the Seine three times in the portion which is already open for service, and as these sections lie in the outlying parts of the town, it was possible to make use of bridges without interfering with street traffic or detracting from the general appearance of the quarter. However, in the newer sections in the centre of the town, this will not be permitted, so that the lines must be taken across the Seine in tunnel. A special bridge was built for the Metropolitan line at Passy, and it is an iron construction measuring 673ft. in length together with the approaches. It has 88ft. total width and contains two different bridge platforms. The main bridge way is used as an ordinary bridge for road traffic and has two side footpaths. Supported from this and upon a series of iron columns is an overhead structure which serves to carry the Metropolitan tracks, the railway bed lying at 23ft. above the bridge level. On the north side, the road comes out of the tunnel and enters directly upon the bridge, but on the south side the bridge is continued by the standard overhead construction already mentioned, this being followed for some

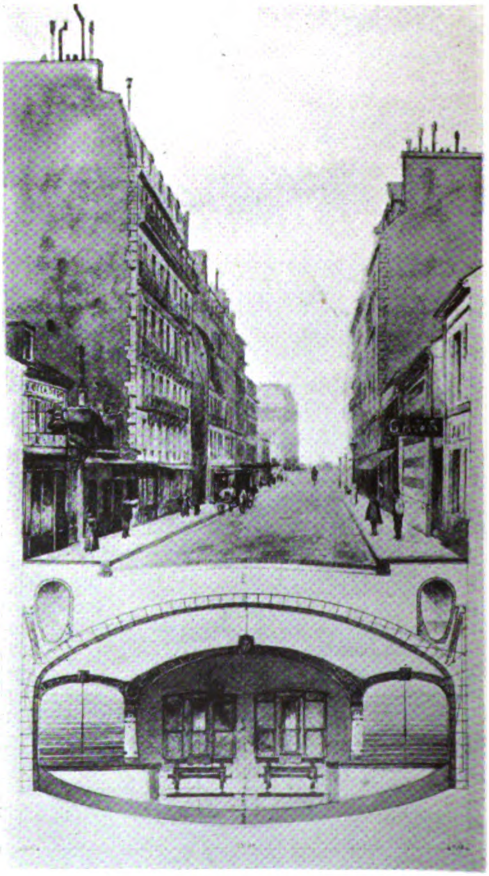


FIG. 5. REINFORCED CONCRETE STATION.

distance. The Metropolitan line again crosses the Seine at a point lying towards the eastern part of town, upon the Austerlitz bridge, which was also built for the Metropolitan system. It is an iron bridge having a 460ft. span, but unlike the former, it is used exclusively for the electric line. A somewhat unique feature is that at one end of the bridge the overhead structure was run through the large building of the Orleans railway depot on a 170ft. bridge truss, and an opening was cut through the building for this purpose. Where the belt-line is taken across the Seine at a point somewhat higher up the river, the already existing Bercy bridge, a masonry structure, was used for the purpose, and to carry the tracks, the bridge was widened and an overhead structure, also of masonry, was built upon it.

One of the leading engineers of the line, M. Bienvenue, has made some interesting calculations regarding the passenger traffic on systems like the Metropolitan. He uses as the basis of his calculations a zone measuring 400 metres wide through which the line passes, and observations show that such width may be taken as the "zone of attraction," it containing the population which is likely to take the subway line. Using this principle, he establishes the relation between the whole number of passengers carried and the population of the zone upon the total length of the line. Thus upon Section No. 1 the population of the zone is 171,000, and the number of passengers carried in a given year 42,000,000. His co-efficient is 246 in this case. The length of the section is 10.5 kilometres, and the number of passengers per kilometre 4,000,000. For some of the other sections of the road he finds co-efficients of 213 and 184. Upon this basis he is able to calculate what will be the approximate figure for the traffic upon the total system of lines in Paris when the project is completed. Thus for the total length of 114.95 kilometres (about 70 miles) the total number of passengers carried annually will be 394,428,000, and the number of passengers per kilometre 3,431,000.

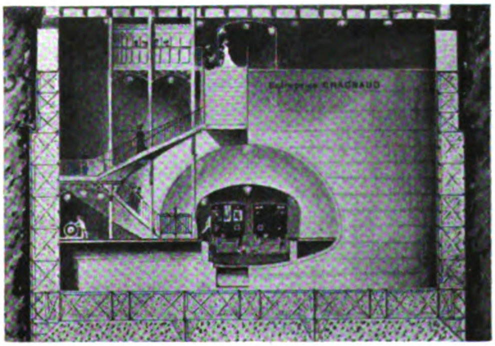


Fig. 6. Showing Access to Station.

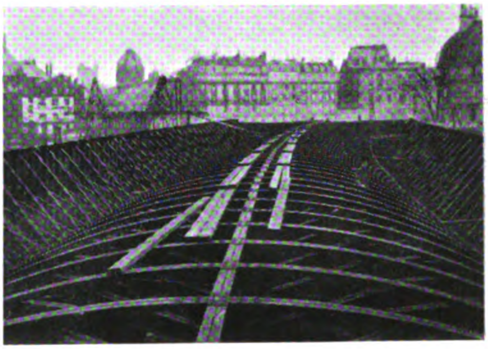


Fig. 7. Caisson Work. Shore End, St. Michel Station.

The Paris subway system presents some special features as concerns the tunnel construction work and the building of several of the subway stations. For these latter, the engineers had a somewhat difficult problem to solve, as the subway runs in some parts of its course under streets which are very narrow, and on this account there was not room between the foundation walls of the houses for constructing a station of masonry which should have the standard outside width. Reinforced concrete was accordingly adopted, and it was found that this material allowed of building the station within the prescribed limits. Another special point in the building of the new subway line is the construction of an iron tube tunnel under the Seine. This work is now being carried on, and it is the first tube

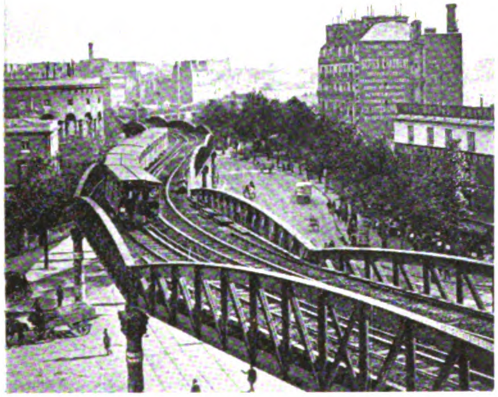


FIG. 8. THE OVERHEAD LINE.

tunnel to be used for subway purposes in France.

As regards the general course of the new section of subway which is known as the North-South subway, it follows a somewhat winding route across the town, but its general direction is from north to south. Starting from the Versailles gate, in the southern city limits, it follows along the narrow but populous Rue de Vaugirard and by the Montparnasse railroad depôt, with which an underground connection will be made so as to give access to the depôt. After this point it follows under two wide boulevards, and reaches the Seine somewhat above the Concorde Bridge. Here the tube tunnel under the Seine commences, each track having a separate tube, and on the other side of the Seine the two tubes come together again at the Place de la Concorde. From this point to the St. Lazare Depôt the subway is obliged to pass underneath narrow streets for the most part. Connection is made at the St. Lazare Depôt by an underground passage for the transfer of passengers, and there is another passage for transferring to the other subway line which crosses at this point. After passing through the narrow Rue d'Amsterdam, where there is a station in reinforced concrete now building, the line runs under a wide avenue to the St. Ouen Gate at the northern city limits. There is also a branch line which passes off at the St. Lazare Depôt and proceeds first eastward and then northward to the Place Jules Joffrin. The total length of the present subway is 8.5 miles.

Most of the subway lines of the city which have already been constructed or laid out are designed to run, for the most part at least, under the wide boulevards and avenues, and on this account there have been no special difficulties encountered in the building of the underground stations. The North-South line, however, has a considerable part of its route under the narrower streets, and, as we have already observed, some special measures had to be taken for constructing the stations in the cases where the standard width required for a masonry station could not be obtained. This is shown in the case of the station which has now been completed in the Rue de Vaugirard in the southern district.

The use of reinforced concrete allowed of reducing the outside width of the construction considerably. For the masonry station of the standard type the outside width is 18.20 metres, and the inside opening representing the width of the station is 13.50 metres, making the thickness of the masonry at each side to be 2.350 metres, as will be observed in the sectional view of the standard station (Fig. 4). The total inside height of the station is 5.900 metres, and the vaulting has an elliptical form, the longer axis of the ellipse being 14.20 metres. The thickness of masonry in the vaulted portion is 0.70 metre at the highest point. For the station platforms on each side of the double track there is allowed a width of 4.10 metres. The tracks, which are of 1.440 metre gauge, are spaced 1.460 metre apart, and the rail level lies at 0.700 metre above the bottom of the station. Opening off the station will be observed the standard tunnel, which has 7.10 metres width. The vaulting of the tunnel is of an elliptical section. This construction for the stations and tunnels is about the same as has been adopted as a standard on the other subway lines of the city.

Comparing the standard underground station with the construction which is adopted for the reinforced concrete station, we find some points of difference. This concerns particularly the outside width of the station. In the Rue de Vaugirard the work had to be adapted first of all to the limiting width which is given by the foundation walls of the houses, this width being but 14.80 metres, which is 3.40 metres less than what is allowed for the standard masonry work. It was found possible, however, to build a reinforced concrete station in this narrow limit, all the while keeping the standard inside width of the station and without changing the inside dimensions to any great extent. The standard width of the platform is also maintained. Using reinforced concrete the side walls can be built of only 0.60 metre thickness as will be observed in the section. The lower portion of the wall is constructed of 0.16 metre thickness, with webs placed at regular intervals for stiffening. This construction is carried out for a height of 2.00 metres, while the remaining 1.10 metres of the height of the wall is built of the standard thickness of 0.60 metres. For the reinforced concrete station there is used a circular arch of 11.0 metre radius which has 0.18 metre thickness of material, but this is braced by a series of stiffening webs. The webs are 0.20 metre thick and are spaced 1.60 metres between centres along the whole length of the vaulting. The maximum thickness measured over the webs is thus 0.60 at the top of the vault. However, the webs are not continuous in section throughout the whole arch of the vaulting, as they diminish on the inside of the arch from the top towards the sides. At the same time the outside web is a maximum at the sides, and diminishes towards the top of the vaulting, so that by this construction the webs lie partly inside and partly outside the arch, keeping all the while the maximum width of the arch at about the same figure.

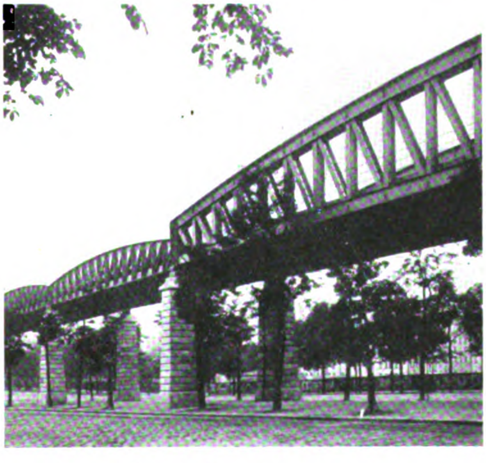


Fig. 9. Typical Overhead Construction.

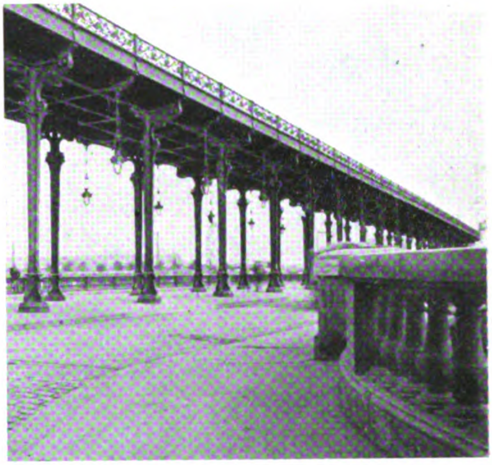


Fig. 10. The Passy Bridge.

The inside height of the station is somewhat greater than before, this being 6.73 metres. The distance from the top of the vault to the level of the street paving is 1.39 metres. As to the total length of the reinforced concrete station, it is about the standard station length. The present reinforced concrete work is carried out on the Consideré system.

In order to provide the foundation which was needed for upholding the side walls of the station, there were sunk in the first place a series of sixty-four shafts underneath

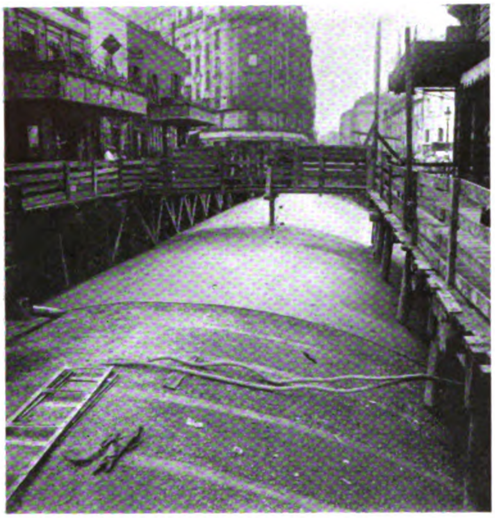


FIG. 11. REINFORCED CONCRETE STATION.

the pathways, the shafts being of 2.40 metres diameter, and these were filled up with beton in order to give a solid support for the walls. For the construction work upon the station there was dug a trench in the street corresponding to the length of the construction, and the work was carried out in the open air. After completing the vault as is here indicated, there was laid a cement filling over the outside which lay flush with the top surface of the ribs, and this gave the vaulting a continuous and smooth surface, such as will be observed in Fig. 11, a view which was taken during the construction.

At one point along the subway line the available width between the foundation walls is so narrow that even the above method of construction cannot be employed. This occurs near the St. Lazare Depôt in the Rue d'Amsterdam, where there is available only 12 metres total width for the entire station. Accordingly another design had to be adopted for this special case, using reinforced concrete as above, but constructing the station in two parts. In the forward half of the station there is a single platform which occupies one side, and the double track takes up the rest of the width. This gives access to the left-hand track. At the end of this portion the tracks make a double curve turn so as to shift the axis of the track towards the left-hand side. This makes the tracks in the succeeding half of the station to occupy the left side instead of the right hand side as before, so that the station platform is here built at the right-hand side of the available space, thus giving access to the right-hand track. The standard width of station platform is retained in this case, and the total length of the double station is 200 metres.

(*To be continued.*)

ELECTRIC STEEL FURNACES.

THE designer of an improved form of induction furnace for steel smelting, Mr. Gustave Gin, gave some interesting particulars of work done in this direction in the course of a paper read at a recent meeting of the Faraday Society. Practice with induction furnaces has shown that it is difficult to obtain a uniform distribution of either the heat or the purifying reactions owing to the low heat conductivity and diffusion of the molten mass. Better results are obtained from the technical point of view by keeping the molten material in continual circulation, as this causes a mixture of all the parts and brings fresh surfaces of the reacting bodies into contact.

Such a circulation has been obtained in the Gin furnaces, which are characterised by a converter composed of two crucibles, both partly filled with the molten material, and having communicating inclined channels, wholly filled with this material. The whole

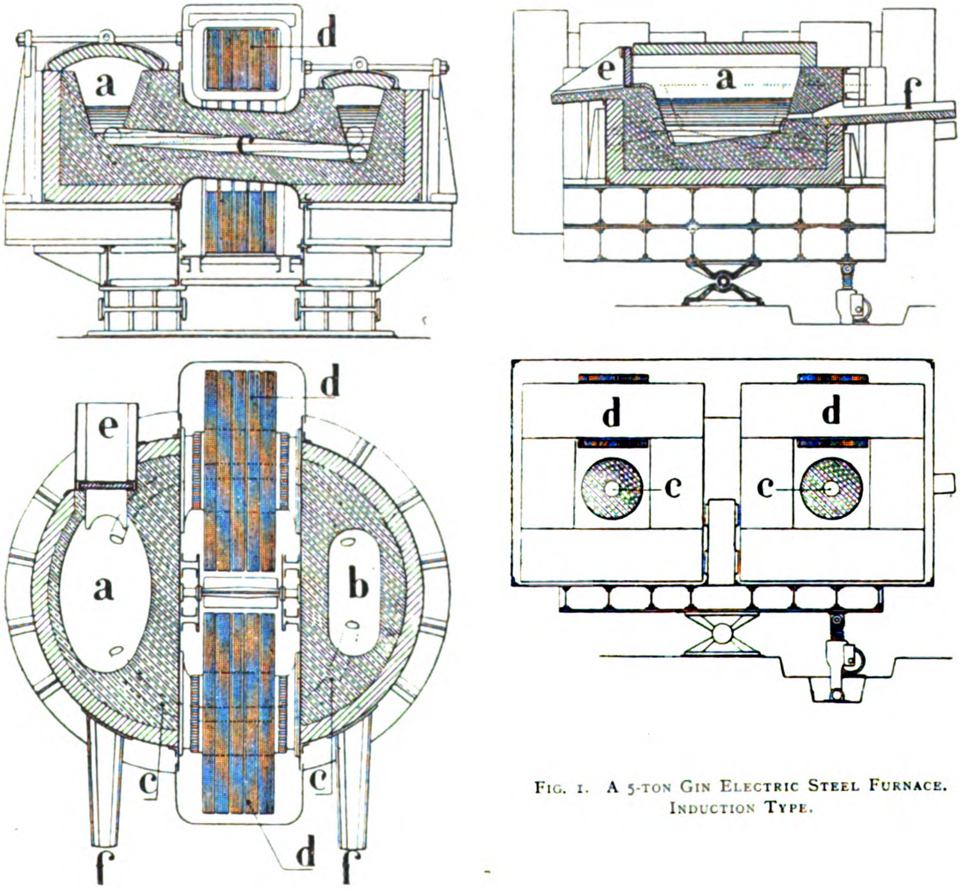


Fig. 1. A 5-ton Gin Electric Steel Furnace. Induction Type.

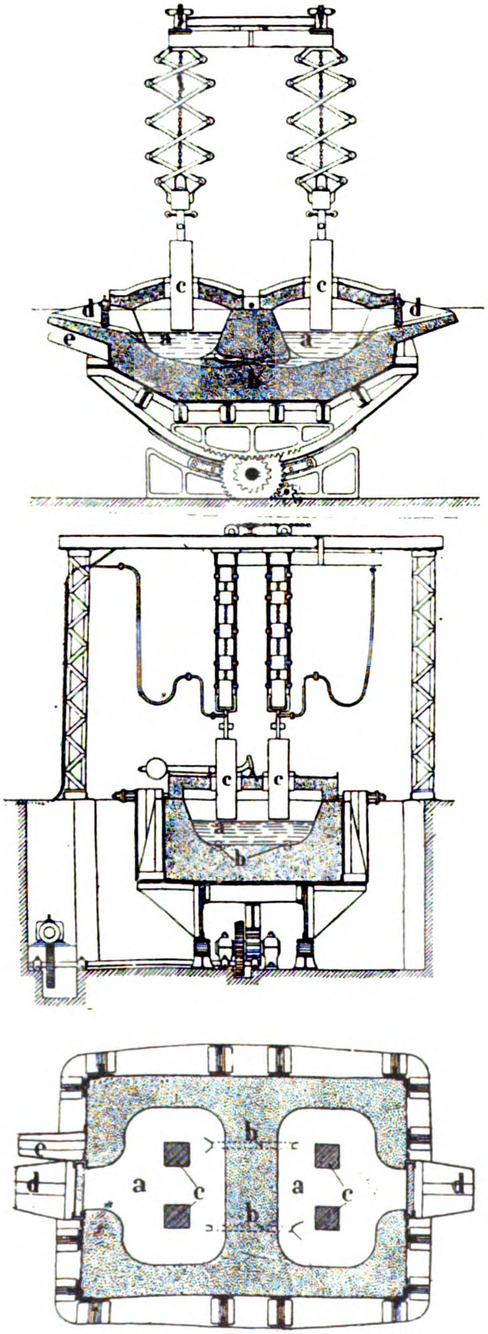


Fig. 2. Gin Electric Furnace. Arc Type.

arrangement forms a closed circuit, through which the heat generated causes a general circulation. This continues owing to the ascending movement which occurs in the connecting channels and is transmitted through the whole molten mass.

The accompanying drawings, Fig. 1, show a model furnace designed by Mr. Gin, with the assistance of MM. Schneider et Cie., for construction at the Krupp Works at Essen. It has a capacity of five tons, and requires a power of 420kw. at a primary pressure of 4800 volts, and a frequency of 5 per second. This furnace consists of two crucibles, *a* and *b*, connected by the heating channel *c*. The larger of the crucibles, *a*, is known as the working crucible, and is fitted with a draw-off door, *e*, for the slag, and a pouring funnel, *f*, for the steel. The primary circuits, *d*, surround the two heating channels, and are cooled by forced ventilation.

To facilitate pouring and the withdrawal of the slag, the whole furnace can be turned about an axis by means of an electrically-driven worm. It is easy to understand why such a furnace should be better from a technical point of view than one with an open connecting channel. The heating is uniform throughout the furnace, and a very high temperature can be obtained without any fear of introducing the "pinch" phenomenon in the heating channels. Every portion of the molten mass comes successively and at a rapid rate into contact with the oxidising slag, thus permitting a much more rapid and complete purification than can be obtained in ordinary furnaces. The speed reached in the channels varies according to their gradient and diameter, but the arrangements are so designed that a minimum velocity of 0.40 metres per second is obtained.

The principle of the foregoing can also be applied to furnaces of the arc type. In these cases the current passes from one electrode to the bath and thence to a second electrode, which is movable like the first, and a purely superficial heating is obtained by means of the two arcs in series. This method is favourable to a high temperature of the slag, but produces an incomplete and non-homogeneous heating of the molten metal in the bath. If the current from a single electrode is passed through the bath to leave by a conducting hearth, an amount of heat is set free in the mass traversed, which is proportional to the electrical resistance of this mass. But if a metal like iron, whose resistance is comparatively low, is being worked with, this quantity of heat is practically negligible, and the useful effect is reduced to the superficial heating produced by the arc between the electrode and the surface of the bath.

In both cases, therefore, the thermal efficiency is low, for the heat conductivity of liquids is small, and the ascending and descending currents which are produced when the source of energy acts on the lower part of the bath cannot be used for the transmission of heat. This disadvantage is remedied by causing the molten mass to be artificially circulated.

To obtain this circulation the furnace shown in the drawings, Fig. 2, has been designed.

In this case the furnace is made up of two crucibles, *a*, connected by inclined channels, *b*, sloping in opposite directions. In the two crucibles are placed the electrodes, *c*, which are connected to an electricity supply. The current passes from the electrode into the bath in the first crucible, and from there into the other bath through the channels, *b*, which serve as conductors both of electricity and heat. Lastly, the current passes from the bath in the second crucible to the corresponding electrode.

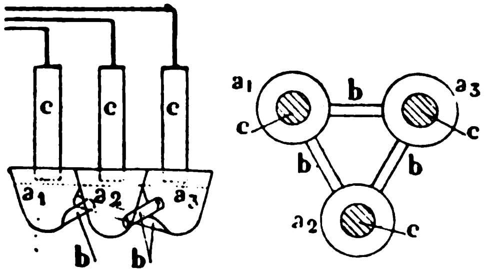


FIG. 3. THREE-PHASE FURNACE.

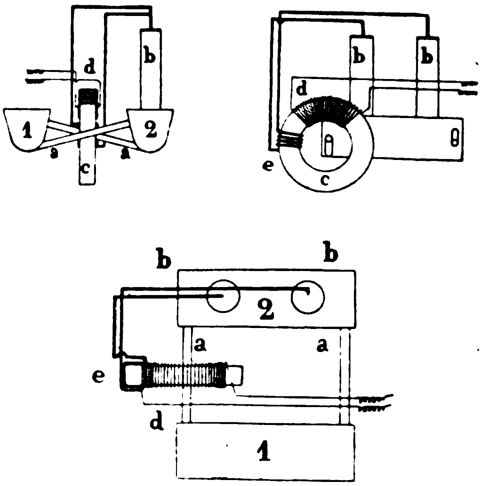


FIG. 4. FURNACE OF COMBINED INDUCTION AND ARC TYPES.

On account of the heating which is produced in the communicating tubes and the difference of level which exists between their two ends, the molten mass rises in them and passes from the first furnace to the second by one of the tubes and in the opposite direction by the other, so that a continuous circulation and even heating is obtained.

In the same way, as shown in Fig. 3, a three-phase furnace can be arranged by connecting three crucibles, a_1, a_2, a_3, by inclined tubes, which serve as both electrical conductors and transmitters of heat. Their gradient is such that the heated liquid circulates continuously from a_1 to a_2, from a_2 to a_3, and from a_3 to a_1. From the electrical point of view the electrodes, *c*, form a triangular group, and it is easy to regulate the load on each by raising or lowering them.

Mr. Gin has designed furnaces on this system for powers of 750kw., 1500kw., and 2500kw., from which 8, 14, and 20 tons of metal can be respectively obtained.

It is interesting to combine the methods of heating by electrodes and induction, when materials containing large quantities of impurities are being used in steel production. In this case refining produces a large quantity of slag whose electrical resistance is very great compared with that of the metal it covers. If the heating is effected simply by induction the transformation of the electrical into thermal energy takes place practically wholly in the metal. The slag being insufficiently heated by its contact with the metal bath, it is difficult to maintain it in a conveniently fluid state or at a temperature suitable for the purifying reactions.

Schneider et Cie. patented a furnace introducing a combination of one or more pairs of electrodes dipping into the furnace and providing additional heat when the arc played between the electodes or between them and the bath. The Rochlingsche Eisen und Stahlwerke and Rodenhauser proposed an electromagnetic arrangement with a special secondary winding, by which a second induced current was sent through the metal bath by means of electrodes embedded in the furnace casing.

These two designs do not allow the simultaneous regulation of the principal and subsidiary heating currents. A mixed furnace which gives better technical results is obtained by employing the arrangements shown in Fig. 4, which represent diagrammatically two crucibles, 1 and 2, connected by channels, *a*, which slope in opposite directions. Round one of these channels is an inductive system, *c*, fitted with a primary winding, *d*, and a secondary winding, *e*. The ends of the latter are connected to two electrodes, *b*, by which current is brought to the surface of the bath in one of the crucibles. As in the ordinary induction furnace, however, the bath made up of crucibles 1 and 2 and the channels *a* forms a secondary winding in which is induced a secondary current that is transformed into heat. An internal heating in the channels and a superficial heating in crucible 2 is thus simultaneously obtained. The electrodes being movable, the resistance of the circuit in which they are connected can be varied at will, and thus the total power distributed according to the working conditions.

It is most important to be able thus to regulate the two currents so as to obtain the best possible operation of the furnace. It may be remarked that a pair of electrodes can be placed in one or in both crucibles.

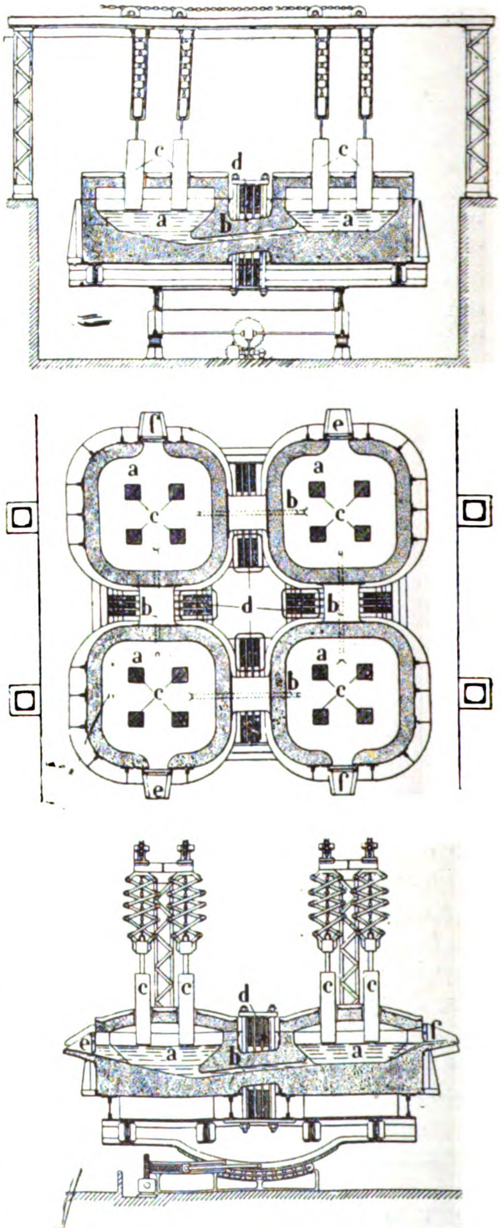


FIG. 5. 50-TON GIN STEEL FURNACE. COMBINED TYPE.

The furnace shown in Fig. 5 has been designed for a power of 6000kw., and can furnish 50 tons of metal at a pouring.

THE "C.M.B." AUTO-CONVERTER.

In the following paper the construction is described, and several applications discussed, of a new type of patent rotary electric transforming machine developed by the authors, for reducing supply voltages for the economical working of metal-filament and arc lamps, for battery charging, gun-fire, and navy-phone circuits, and also for balancing three-wire circuits.

The lines along which this machine has been developed are easily followed by reference to Figs. 1, 2, &c.

Fig. 1 shows an ordinary two-pole dynamo-electric machine in which *n* and *s* represent the field poles, and *a a* the main brushes. If cross brushes *b b* are placed on the commutator and short-circuited, and if the primary supply voltage is represented by *P*, then this may be reduced to any desired value represented by *S*, depending chiefly on the position of the short-circuited brushes *b b* on the commutator in relation to the main brushes *a a*.

The machine as shown in Fig. 1 would have several serious defects, viz.,

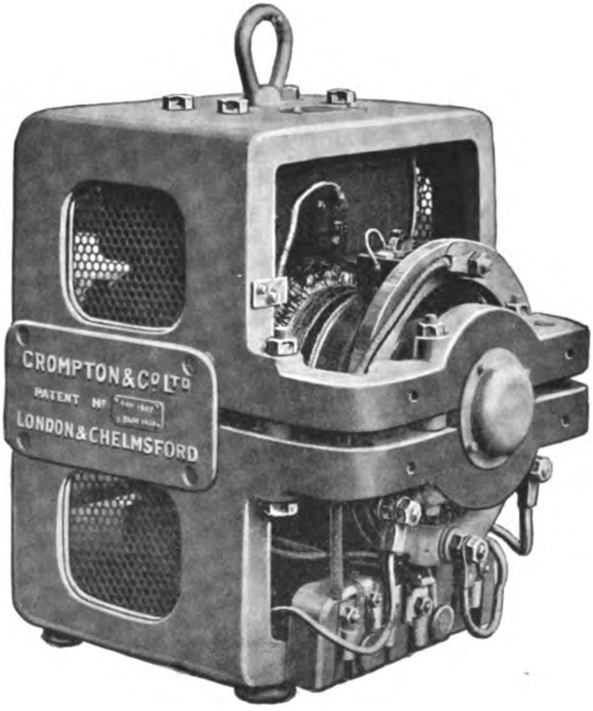
1. The presence of the iron poles *n s* immediately over the shorted brushes *b b* would not permit of sparkless commutation at these brushes.

2. It would not be possible to regulate the secondary voltage *S*, either automatically or by hand.

3. The m.m.f. of armature reaction would cause a large cross-flux to pass through the armature between the shorted brushes across the pole faces, as shown by the dotted lines in Fig. 1. The armature revolving in this flux would create a large circulating current in the shorted brushes—either causing the machine to race dangerously, or lose speed. Such a circulating current would also be very wasteful, and would tend to make one of the short-circuited brushes spark more than the other.

4. The weight of the field magnets and space occupied would be excessive.

The method adopted to get over the sparking difficulty has been to sub-divide the poles into two parts, to correspond with the position of the shorted brushes. This step is shown in Fig. 2, where the poles are shown divided unequally, as would be re-



THE "C.M.B." AUTO-CONVERTER.

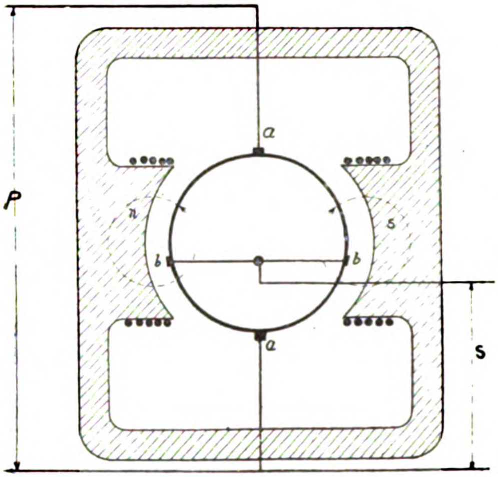


FIG. 1.

quired for an unequal division of the voltage.

It will be noted that when the e.m.f. applied to brushes *a a* is to be split unequally that the field should be divided unequally, and the shorted brushes should divide the armature in a corresponding manner, as this will lead to greater efficiency and economy in material. In reducing from a constant potential of 220 to a constant potential of 50, say, the part pole ratios should be approximately 2 : 1 for maximum economy.

If the supply voltage is constant, and the speed of rotation is to remain unchanged, any increase of flux on one side of the shorted brushes must necessarily take place at the expense of the flux on the other side. In order to regulate the secondary voltage, therefore, or compensate for voltage drop in the converter, the authors provide the machine with a ring wound armature, and entirely isolate the two magnetic circuits from one another. It should be noted that it is quite impossible to get any regulation of the secondary voltage without absolutely isolating the one magnetic circuit from the other, and also impossible to prevent wasteful circulating currents in the shorted brushes. It is obvious that the machine in Fig. 2 would be unsatisfactory for two reasons; firstly, because any reduction in the m.m.f. on poles n_1 and s_1 say, and a corresponding increase in n_2 s_2, would have no effect on the quantity of flux passing through the two parts of the armature, thus preventing any alteration to the division of voltage; secondly, the armature reaction flux has still a low resistance path, as indicated by the dotted lines in this figure.

As mentioned above, a variation of the voltage on either side of the shorted brushes cannot take place unless a ring armature is used, due to the fact that the armature conductor of a drum armature spans across the pole pitch.

The construction adopted for completely isolating the magnetic circuits, shown diagrammatically in Fig. 3, consists primarily in placing the pole parts n_1 s_1 n_2 s_2 into a vertical position with relation to the plane passing through the shorted brushes. It will be seen from the diagram that the length of the mean resistance path for the flux, due to the armature m.m.f., is increased considerably, and that as the yoke length is shortened the weight and cost must be considerably reduced.

Although all the precautions as outlined above were taken in the earlier designs, these machines still gave considerable trouble, due to the short-circuit current flowing through the armature across the shorted brushes. As already stated, this short-circuit current, if not properly controlled, makes the operation of such a machine practically impossible;

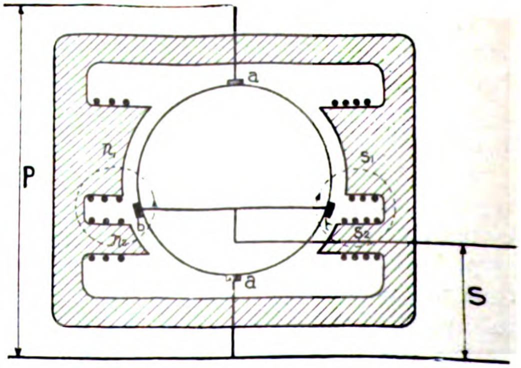


FIG. 2.

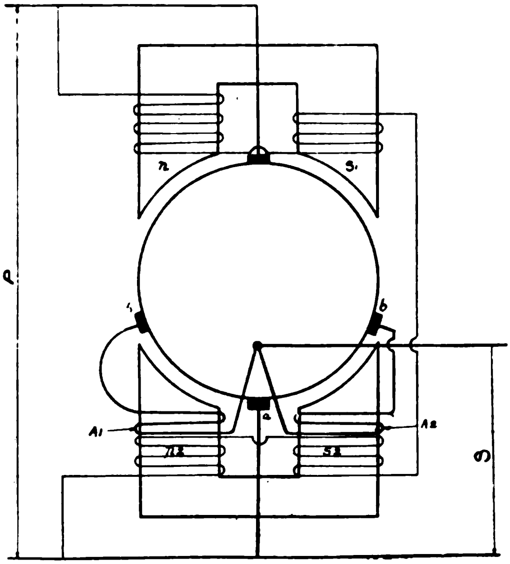


FIG. 3.

and it was found in the earlier machines referred to above that there was a very great liability for the machines to take charge and race dangerously, more especially when the secondary voltage was varied between wide limits. This of course is due to the fact that the armature reaction, caused by the circulating current, in this case may be in direct opposition to the m.m.f. on the main field poles, resulting in a demagnetization of these poles, and raising the speed.

To get over this difficulty in the most effective and simple manner possible, the poles are provided with series windings in addition to the ordinary shunt coils, and connected as shown in Fig. 3, where *A*1 and *A*2 represent the series coils. These coils are each connected to one of the shorted brushes, and their other ends connected together at one of the secondary terminals of the machine. Under normal circumstances, when there is no circulating current flowing through the armature across the shorted brushes, then each brush and each main coil will be carrying half the secondary load current; if, however, a circulating current arises, it will flow in opposition to the load current in one coil, *A*1 say, and in conjunction with the load current in the other coil, *A*2. In effect, therefore, the current in coil *A*1 will be less than in coil *A*2, and if these coils are suitably coupled up will have the effect of correcting or preventing the short-circuit current from rising to any considerable value. In other words, as the current in the coil *A*1 is less than the current in the coil *A*2, the m.m.f. on pole n_2 is less than the m.m.f. on the pole s_2, and this tends to cause a greater voltage to be generated under the pole s_2 than under the pole n_2, thus opposing the voltage which is creating the circulating current.

A little consideration will show that these balancing series coils can be placed on all the poles, and can be wound, not only to effect the governing of the circulating current, but also at the same time to create either a compounding or differential effect on the secondary circuit.

When these series coils are used there is no tendency for the machine to race, and the currents coming from each of the shorted brushes are always within 10 per cent. of each other, even when the magnet poles are

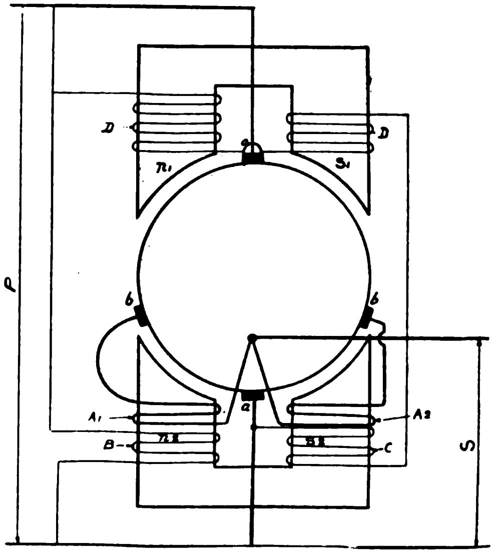


FIG. 4.

entirely unsaturated, which would be impossible without these windings.

These converters may be divided into three classes, depending on the use to which they are to be put:—

(*a*) For giving a constant secondary voltage for any value of the secondary current.

(*b*) For giving a secondary current which is to remain approximately constant for a given range of secondary voltage.

(*c*) Machines which are to be used for converting from alternating to direct current, the direct-current voltage being capable of variation without affecting the power factor of the alternating side.

As a general rule the coupling diagram as shown in Fig. 3 is suitable for machines giving constant voltage. Such machines would be the direct-current equivalent of an alternating-current auto-transformer, but would have the advantage that the secondary voltage could be easily altered at will, independently of the primary voltage, or compounded for voltage drop. As machines of this class, having a capacity of between 2kw. and 3kw., will have an efficiency of from 75 per cent. to 80 per cent., it is obvious that their application to transforming the voltage for metallic-filament lamps has led to very good results in many cases.

For instance, in large shops, hotels, and theatres, when the full load can be switched on at once and kept on for a considerable time, the saving will be something like 70 per cent. in power over the most efficient carbon lamp.

The secondary voltage can be made to vary up or down, either automatically or by hand regulation, to suit the various conditions to which the machines may be applied.

In all the above cases it is desirable to arrange the values of the ampere turns on the poles on both sides of the shorted brushes so that both poles and yokes are unsaturated magnetically. This permits of good regulation and perfect governing for short-circuit current.

With the poles on the primary side of the shorted brushes, viz., $n_1 s_1$, absolutely unsaturated magnetically, and the poles on the secondary side highly saturated, it is possible to use this machine by applying a fly-wheel to its shaft, for reducing the voltage from a tramway trolley circuit to, say, 220 or 110 volts, and at the same time to smooth out the variations in voltage on the secondary side, so that the machine can be used for supplying incandescent lighting successfully from its secondary terminals. With the usual variation of pressure of a tramway circuit, a practically constant voltage can be obtained at the secondary terminals of the machine.

The machines have also been applied to balancing three-wire circuits with great success, the largest as yet made being two machines for the Calcutta Electric Supply Corporation, dealing with an out-of-balance load of 60kw. on either side of the middle wire, the voltage of the outers varying from 460 to 580 volts. These machines were required to balance the voltage within one per cent. of the mean value on either side of the middle wire at all voltages between 460 and 580. Their efficiency was 94 per cent. on test, which is 4 per cent. or 5 per cent. higher than that obtained with double machines.

The advantages of using such machines as balancers are the small weight and space taken up, absolute reliability, small wear and tear on the brushes, and high efficiency.

When used as a balancer the armature is divided into two equal parts by the shorted brushes; also the polar limbs are all equal in dimensions, the series compounding coils are arranged on all the poles, not only for the purpose of voltage regulation, but also to balance the circulating current across the shorted brushes.

From the foregoing it will be seen that

there is an unlimited field for the use of this converter, owing to the high efficiency and small space required.

We will now describe briefly the construction of the machine used for the purpose set forth under heading (*b*), having a constant secondary current over a given range of secondary voltage. The characteristic of the secondary is shown by the curve in Fig. 5, and is suitable for supplying a single arc lamp, or two or more arc lamps in series, without the use of steadying resistances.

Fig. 4 shows the winding diagram of the machine arranged to give automatically a practically constant secondary current. On examining this diagram it will be noticed that the shunt winding on the part poles $n_1 s_1$ are connected between the positive supply main and the shorted brushes, whereas the shunt coil marked *B* is connected right across the supply mains. The shunt coil *C* is connected between the shorted brushes and the negative supply main. The series coils *A*1 *A*2 on the part poles n_2 s_2 are each connected to a shorted brush, in the same way as described with reference to Fig. 3, but in this case the series coils *A*1 *A*2 are so connected that their m.m.f.'s oppose the m.m.f.'s of the shunt coils *B* and *C*. The action of the machine is as follows:—

If the secondary current tends to increase, the opposition m.m.f.'s of the series windings *A*1 *A*2 are increased, which reduces the secondary voltage *S*, the presence of the separately excited coil *B* preventing the flux in the poles n_2 s_2 being wiped out altogether. The secondary voltage having dropped, the voltage between the shorted brushes and the position main brushes must rise, causing the shunt coils *D* to increase the flux through the part poles n_1 s_1, thereby replacing the flux withdrawn from the part poles n_2 s_2, and so keeping the speed constant.

When under load the armature is divided into a motor portion and a generator portion by the shorted brushes, and the m.m.f. of the motor part will be in opposition to that of the generator part. With a certain transformation ratio these m.m.f.'s are equal and opposite, but in the case of the arc lamp converter just described, on approaching the short-circuit condition the m.m.f. of the generator portion is much greater than the motor part, and a cross-flux already referred to passes between the shorted brushes, following the path shown by the dotted lines in Fig. 1, causing a large parasitic current to flow between the shorted brushes. This cross-flux can be neutralised by strengthening the m.m.f. in the pole n_2 and weakening s_2, and the parasitic current traversing the coils *A*1 *A*2 performs this function to a great extent, but to entirely neutralise the cross-flux the authors place the shunt coil *B*, which maintains its strength throughout, on the pole n_2, and the coil *C*—which becomes gradually weaker towards short circuit—on the pole s_2.

These machines are absolutely automatic in their action, and will run for any length of time on open circuit, full load, or with the secondary terminals of the machine short-circuited for any length of time. They can be worked with perfect safety to the operator, and no damage can be done to the lamp, as the current can never exceed the full-load working current. In cases where the lamp has to strike automatically, this is insured by the fact that when the carbons are brought together there is an instantaneous rush of current of about twice the full-load working current, which makes the lamp strike. This current settles down to the full-load value in less than a second, and if the lamp does not strike, the machine merely allows normal current to pass through the shorted carbons. A variation in the secondary characteristic can be produced by inserting a shunt regulator. Similarly, a constant current of practically any value covering a very wide range, can be obtained for a given range of voltage by merely fixing the position of a shunt regulator handle.

Fig. 5 shows some actual curves taken from a test on a machine. The curve is

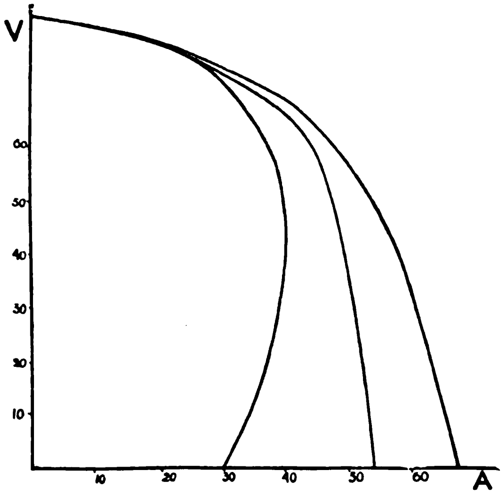


Fig. 5.

vertical, and one might suppose there would be instability when working on the vertical part of the curve. This is not the case, as it is quite possible to arrange these machines to work two arc lamps in series. When one lamp only is working, the other being short-circuited, the machine is quite stable, and supplies the remaining lamp satisfactorily with the same current, but at a lower voltage. As far as the authors are aware, this is the first time such a result has been obtained.

The various characteristic curves, as shown in Fig. 5, are produced by altering the resistance in circuit with the shunt coil *B*, and this being an extremely simple thing to do such a machine is specially adapted for working a cinematograph, and in fact any kind of projector lamp, because of the ease with which the light intensity can be altered, by adjusting the amount of current passing through the arc, 50 per cent. above or below the normal.

It is possible with such a machine to place it at a long distance from the operator and merely bring two small wires to the shunt regulator at the operator's hand; any alteration to the intensity of the light can be obtained by adjusting the shunt regulator handle.

A cinematograph machine capable of giving a supply of 50amp. to a 50-volt arc is 22in. high by 21in. wide by 14in. long, and weighs 5cwt. The efficiency of such a machine works out at from 75 per cent. to 80 per cent. on full load, and it will therefore save, when replacing a steadying resistance worked off a 440 volt circuit, about £13 per week; when replacing a steadying resistance worked off a 220-volt supply, some £5 per week; and when replacing a steadying resistance worked off a 110-volt supply, the saving will be about £1 10s. per week. These figures are based on the assumption that the price of current is 3d. per unit, and that the lamps are used for fifty hours per week. The price paid for such an installation, working on these assumptions, will be saved in the first case in four weeks, in the second case in about ten weeks, and in the third case about thirty-five weeks.

In electric welding any of the characteristics shown in Fig. 5 will be suitable. The

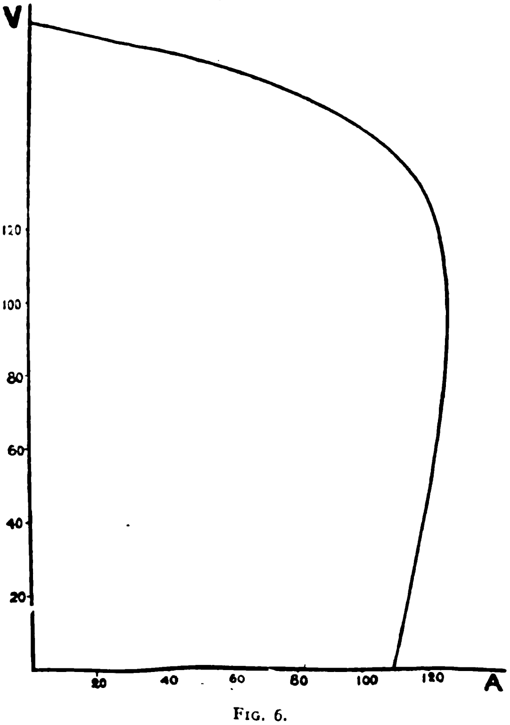


Fig. 6.

primary supply voltage should be low, for the machine can be made rather lighter, more efficient, and of better proportions, the lower the primary supply voltage.

A very good portable welding set could be made by supplying in conjunction with such a machine an 80 or 90 volt battery capable of giving high discharges for short periods.

Fig. 6 shows the relationship between the secondary amperes and voltage of a 220-volt machine made for the purpose of supplying two 120amp. 60-volt arc lamps in series. The efficiency of this machine, when supplying the two lamps in series, was over 92 per cent. The dimensions of the machine are 24in. high by 22in. wide by 24in. long, and it weighs 8cwt. net.

The weight of the set and the space taken up have probably never been reached before within 100 per cent.

The weight and the space taken up are remarkably small, when it is considered that each part of the armature, and each part of the field system, has to be capable of dealing with the full primary voltage and the full secondary current at the same time.

Under heading (*c*) are machines which are used for converting alternating currents to direct currents; these are really the machines which come under headings (*a*) and (*b*) supplied with a suitable number of collector rings to suit the number of the phases of the supply. The advantages to be obtained by using such machines for this purpose are as follows:—The direct-current voltage taken from the secondary is more or less independent of the alternating supply voltage, and can be varied either automatically or by hand without altering the power factor of the alternating-current supply to any appreciable extent. It is evident, therefore, that machines of this kind can be used for all the purposes set forth under headings (*a*) and (*b*) by applying similar windings to the part poles n_1 s_1 and n_2 s_2, and when supplied with collector rings and a belt pulley this machine is extremely valuable for teaching purposes in technical colleges.

With the cross brushes up such a machine can be used as a direct-current dynamo, a direct-current motor, an alternating-current dynamo, an alternating-current motor, a combined direct and alternating current dynamo, a split pole rotary converter. With the cross brushes down it can be used as a direct-current auto-transformer, converting if desired from constant potential to constant current, and again as a rotary converter, converting from alternating to direct current of practically any voltage between given limits.

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and
H. BURGE, A.M.I.C.E., A.M.I.E.E.

ELECTRIC-DRIVEN ROLLING MILLS.[*]

THE introduction of the electric drive in rolling mills has made it possible to clear up many points in regard to power required for rolling different shapes of steel, and, moreover, the roller, or operator, is able to see at a glance the work done by each pass. The electric roll drive has also taught us how to get the best relation among rotating masses, speed, time, and horse power. It has helped the roll designer to calibrate rolls in such a manner that the power characteristic for all the passes is uniform, thereby avoiding high power peaks, decreasing the size of the prime mover, and reducing first cost and fuel consumption.

The watt-hour meter warns the roller should bearings or rolls become tight and hot, or indicates that the steel is causing excessive friction in the passes, often due to overfilling, cold steel or faulty calibration, thereby guarding against damage to the rolls and bearings. The meter indicates that lower heat, greater elongation, and especially change of profile in different directions, increase the power required at the rolls much more rapidly than do chemical hardness, high tensile strength, or larger draughts. The meter also shows that it is not the higher percentage of carbon in steel which requires more power in rolling, but the lower temperatures at which this steel has to be rolled, and also that an increase in width of the steel shape requires more power than a decrease in height. By means of the meter, too, it can readily be seen that rolling "squares" and "rounds" takes, per square inch displacement, much less power than shapes with large peripheries and many flanges, because the latter cool off quickly and cause much friction in the rolls.

Tests on rail-mills have shown that the foot-pounds per square inch of displacement gradually increase the nearer the rail is to the finishing pass. A 75lb. rail required 1100ft.-lb. at the first pass on the first "rougher." On the same stand in the seventh pass it required 3000ft.-lb.; in the first pass on the second roughing rolls 4800ft.-lb., in the fifth pass 8150ft.-lb.; 9500ft.-lb. were required for the last or finishing pass. The large increase in foot-pounds is mainly due to the greater density and rapid cooling of the steel, especially at the thinner flanges near the finishing pass. For this reason, the flanges are rolled out as late as possible. Whenever required, exact power consumption can be given for each phase of rolling.

The ideal motive power for rolls should drive them slowly when the steel enters and should drive the roll faster as the piece lengthens. The reciprocating engine will do just the reverse; namely, run very fast without load, and slow down as the load increases, finally stopping if the load becomes too great.

The maximum torque of reciprocating engines is fixed by the size of the cylinders and the steam pressure; it cannot be increased no matter how much steam is available. For this reason most mill engines are made very large, and often run with only half load, causing high steam consumption per horse power, their most economical cut-off being at full load.

For this work the characteristics of the electric motor are much better. Even with double its full torque, the efficiency is good and the motor will not stop, but will take more and more current, finally becoming overheated and burning unless properly protected. If desirable, its speed changes from no load to full load can be made small. The current can also be limited to a certain maximum, without stopping the motor, in this manner preventing excessive strains and probably serious breakdowns.

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[*] Paper read by E. Friedlander before the American Institute of Electrical Engineers, June 28, 1909.

Where high speeds are necessary, motors can be direct connected to rolls, increasing the energy of the rotating parts, and at the same time decreasing the size of motor, the power required, and the fuel consumption. Heavy reciprocating engines cannot run at such high speeds, and must be connected to the rolls by means of gears, ropes, or belts.

To obtain accurate information as to the exact power requirements for rolling steel, indicator diagrams were taken on reciprocating engines doing similar work, but these in many instances were misleading. The work of rolling steel is very changeable and intermittent. Engines often run with light loads, but at short intervals have their valves wide open. This, together with the work done due to the energy of the rotating parts, should be carefully observed. Although it is probably not difficult to get the maximum torque required to decide on the normal capacity of the motor, the above mentioned points must be considered, together with the length and number of pieces in the rolls, and also the time-intervals between passes. To be on the safe side it is advisable to follow standard mill practice and make motors of ample size and strength, in order to stand the severe service and overloads without injury.

In mentioning fly-wheels the writer had only three-high non-reversible mills in mind. As the weight of rotating parts is much greater in large motors than in reciprocating engines, and the energy of the rotating part increases as the square of the speed, it is obvious that even a small change in speed is of great importance. As tests have shown that rotating masses are sometimes not only of no use but that they often prove a drag on the motor, careful study of this feature has to be made in each case.

While the steel is being rolled, both the motor and the fly-wheel should furnish the power, but as soon as the steel leaves the rolls the motor should accelerate the rotating masses to the same speed as before rolling. The time available and the number of revolutions will determine the size of the motor more than anything else.

It has been observed that on blooming and roughing mills, where the pieces are very short and the intervals long, rotating masses supply the largest part of energy during the rolling period and should therefore be large. The reverse takes place at the finishing passes, where pieces are long and follow each other rapidly. Heavy rotating masses would in this case be useless, and would even require larger motors for their quick acceleration.

Where one motor drives roughing and finishing rolls, curves should be plotted showing the number of pieces in the rolls at the same time, the length of passes and intervals, the power required for each pass, &c. With the help of such curves the best relation between the sizes and speed of the motor and fly-wheel, radius of gyration, and slip of motor can be easily determined.

The total motive power required in a steel plant is changeable and fluctuates continuously, the average in many plants being often below one-fourth of the total horse power installed in motors. The electric-driven rolling mills will, however, demand considerably larger power-stations to take care of the large currents, especially when all the motors happen to be overloaded at one time, as for instance when rolling cold steel. It is very important to find out beforehand how much of this fluctuating load the power house may have to supply, assuming the worst conditions, as the shut-down of the electric power station for even a very short time will stop the operation of a large number of machines and cause enormous losses. This is the one very objectionable feature of making such a great number of prime movers entirely dependent on one power station, and therefore some means should be taken to prevent this disturbance.

With steam engines and boilers the liability of a complete shutdown is not so great, but the delays and annoyances caused by low steam pressure are of daily occurrence in many plants. In such cases not only will all the steam-driven prime movers be unable to develop the required power, but also in trying to develop this power, they will use more and more steam, thus making it difficult to raise the steam pressure without increasing the number of boilers, or decreasing for a while the load and consequently the production.

The short high-peaked current demands should be kept off the power station as much as possible and only the average current be supplied. The least number of units can then be kept running under nearly full load with the most economical fuel consumption and the least wear and tear of moving parts. As before mentioned the average current consumption in a steel plant is always small in comparison with the motor capacity on account of the intermittent work and large amount of inertia of the rotating parts. By means of storage-batteries or fly-wheel sub-stations the occasional large demands for current can be taken off the station and supplied from these two sources, where it is stored up when the current demand is below the average.

The exchange of current from one motor to another, in connection with electric roll-drives, is often considerable and should not be overlooked.

With regard to the electric reversing mill, it is a fact that soon after its first appearance the use of reversing rolls became more general, especially in England and Germany. In those countries, small quantities of one kind and shape of material are rolled, and the cost of the large number of rolls required and the saving of time in changing rolls are probably the chief reasons for using the reversing mill, where many different sections can be worked with the same rolls. The absence of the heavy and troublesome lifting tables is also a welcome feature, especially when pieces rolled are very long.

The first installation in America of an electric reversing mill, at the Illinois Steel Company's works at South Chicago, has given entire satisfaction from the start, and has demonstrated that the electric motor is much better adapted for this kind of work than the reciprocating engine. Although the first cost was high, its lower depreciation, better operation and lower cost of maintenance should justify its installation.

In a reversing mill the operator is able to draw steel slowly into the rolls and "speed up" while the piece lengthens, making a great advantage in rolling steel. In order to obtain perfect speed regulation, no use can be made of steam expansion, but admission continues during nearly full stroke. Even then much depends on the skill of the operator, who can subject the engine and the mill to very severe shocks and cause serious breakdowns if he is not careful. Reversing mills are therefore made heavy and strong. If too much steam is admitted, it is difficult to prevent such large engines from racing without load. It is also wasteful, as both the time of actual rolling and the speed of the rolls are limited, most of the power being consumed in the rapid starting and stopping of the heavy rotating parts, without making any use of their fly-wheel energy.

With the use of electric motors in place of reciprocating engines, the problem of reversing rolls becomes much simpler and better, in regard to manipulation, fuel consumption, and cost of maintenance. Operation of electric-driven reversing mills is nearly automatic; no skilled operator is required and all danger to the motor and the mill is eliminated. The speed of acceleration is prearranged, and no matter how fast the operator moves his levers, the maximum current and the speed are limited.

Reversing is done with the least shocks in rolls and couplings, and the danger of over-straining machinery is done away with. It is important to be able to reverse the motor just as rapidly as the engine. Special care should therefore be taken to have a motor-generator that will give large currents with very low excitation, and one that will be quickly magnetized and de-magnetized.

It has been observed that only one-fourth of the power required at the reversing-roll motor is the average supplied from the power station. The large current demands are furnished by the motor-generator through the energy of the high-speed fly-wheel, and a considerable amount of current is sometimes sent back into the line.

As for all other mill work where power and speed variation are considerable, the direct-current motor, on account of its load and speed characteristics, is better adapted for driving rolls than the alternating-current motor. For reversible roll drives it is used exclusively.

There is no reason why the direct-current motor should give any more trouble than the direct-current generator at the power station. Four years' experience has shown that the wear of the commutator and the cost of maintenance amount to practically nothing. The transmission of large low-tension currents is much more serious, especially when tens of thousands of horse-power have to be supplied and the distance of the motors from the station is considerable.

The use of higher direct current voltages in connection with large rolling-mill motors should be satisfactory; but no doubt high-tension alternating-current transmission and induction motors direct on the line will be generally employed, especially in new installations. Where conditions demand it, the induction motor characteristics can now be made nearly similar to the compound-wound, direct-current motor. However, much of its simplicity and efficiency will be sacrificed in doing this.

Among some of the earlier disadvantages of the induction motor were: very large current required for starting under heavy load; one speed fixed by the number of poles and the tendency always to run at synchronous speed; low power-factor with light loads; small air gaps; impracticability of reversing large units; and inability to change speed to fly-wheel requirements.

In the design of the modern rolling-mill motor, most of these objectionable points have been remedied by different means, such as wound rotors, the introduction of variable resistance, changing the number of poles, shifting the phases, slip-rings, &c.

Whether direct-current power stations and direct-current motors are used, or alternating-current stations are installed for high-tension transmission with alternating-current motors directly on the line or fed through transformers, or direct-current motors are supplied from an alternating-current station through converters, or motor-generators, batteries, or fly-wheel sub-stations, is a matter of detail. No doubt any one of these systems will give satisfaction if properly designed and installed.

* * *

LOCOMOTIVE ASHES AND SMOKE-BOX BREEZE.

The disposal of the waste products of combustion of the locomotives used in our railway service is a problem which should appeal to engineers from a considerable number of standpoints. In the first place, the tendency is evident on the part of the railway companies to economise in operating costs as much as ever possible by the reduction of hand labour to the lowest point compatible with safety in running, and to this end mechanical and automatic or semi-automatic appliances are being included in railway equipment to a much larger extent than was formerly the case. Again, the railway companies are by no means in a position to neglect the chances of utilising a waste product, or, as it may now more fittingly be called, a bye-product, to the best possible advantage. A third consideration is that the lesson of recent years, when the shortage in the supply of good class coal for locomotive purposes was only too evident, should not be neglected, and effort should be made to secure a means of disposal of waste products which will neutralise or minimise the losses due to burning inferior coal. It is apparent that if a suitable market can be obtained for the disposal of unconsumed portions of the fuel at a profitable figure, the same despondency

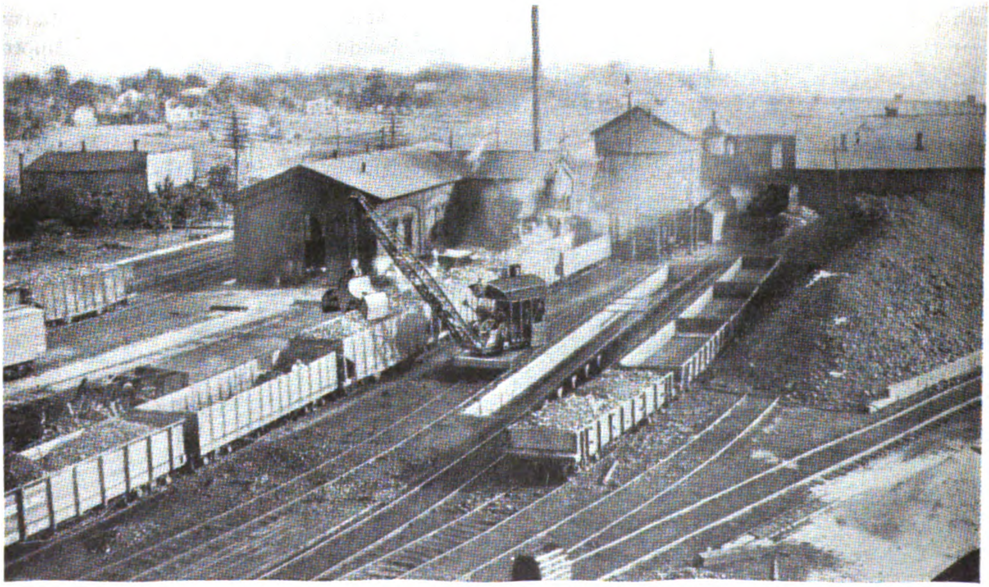

Fig. 1. Four-wheel "Brownhoist" Locomotive Coaling Crane. Showing also the track arrangement for fuel and ash handling. New York, Chicago, and St. Louis Railway.

need not be felt as is at present the case if the highest calorific value per pound of coal cannot be obtained. Coaling and cleaning may be more frequent, but the trouble is certainly minimised if a satisfactory use can be found for the smoke box breeze.

It is, therefore, worth while examining the methods at present in use on British railways for the disposal of ash and breeze, and then to see whether some improvements cannot be effected whose result will be the reduction of fuel cost per train mile. So far as the writer is aware, the position at present in England is not particularly satisfactory. The method usually adopted is to empty the contents of the smoke box and the ash pit out on to the ground or into a pit at any convenient siding adjacent to the cleaning and coaling sheds, and to let it remain there until a gang of labourers can be told off to shovel the refuse into trucks which are then hauled to some tip, or else the contents sold, at a price which does not pay for haulage, to a building contractor. Some improvements on these methods can surely be adopted, and the best course to pursue is suggested by a review of what has been done elsewhere.

Taking first of all the question of economic handling of the refuse, the railway companies of the United States have already given us an indication of what may be done in this direction. The installation of conveying machinery such as buckets and grabs for the purpose of loading the locomotive tenders either from storage piles at the side of the track, or from specially constructed storage bins, has long been an established feature of American practice, and in connection with these it has been found that much of the machinery which is used in coaling operations may also be used for removing ashes and breeze. In many of these installations the locomotive crane is the means adopted for handling, the grab being shaped in such a way that it will dig easily into fine, closely compacted material, such as cinder and flue dust, the entire weight of the bucket resting on the cutting edges of the spades. The buckets are constructed so as to have a very wide spread when open, and are designed so that they will thoroughly search

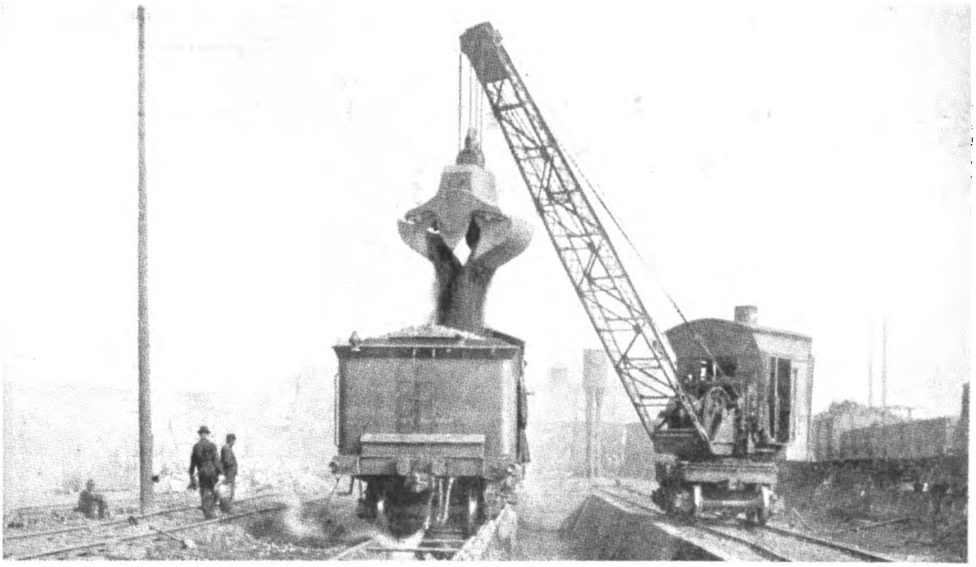

FIG. 2. EIGHT-WHEEL "BROWNHOIST" LOCOMOTIVE COALING AND ASH-LOADING CRANE.

the corner of a truck without the intervention of much manual aid. Fig. 1 shows the arrangement of truck and ash pit adopted at the Bellevue coaling station of the New York, Chicago and St. Louis Railway Company, and particular attention may be drawn to the arrangement of the fourth track entering the picture, counting from the right. It will be seen that for a certain portion of its length this runs on trestle work, the bottom of the track being open. At the side of the track, and communicating with it through the openings in the trestle work, is a long pit some 4ft. in depth. A locomotive whose refuse is to be removed is run on to this track, and its fire box, smoke box, and tubes cleared, the displaced material falling into the pit underneath, and so into the side pit. In this

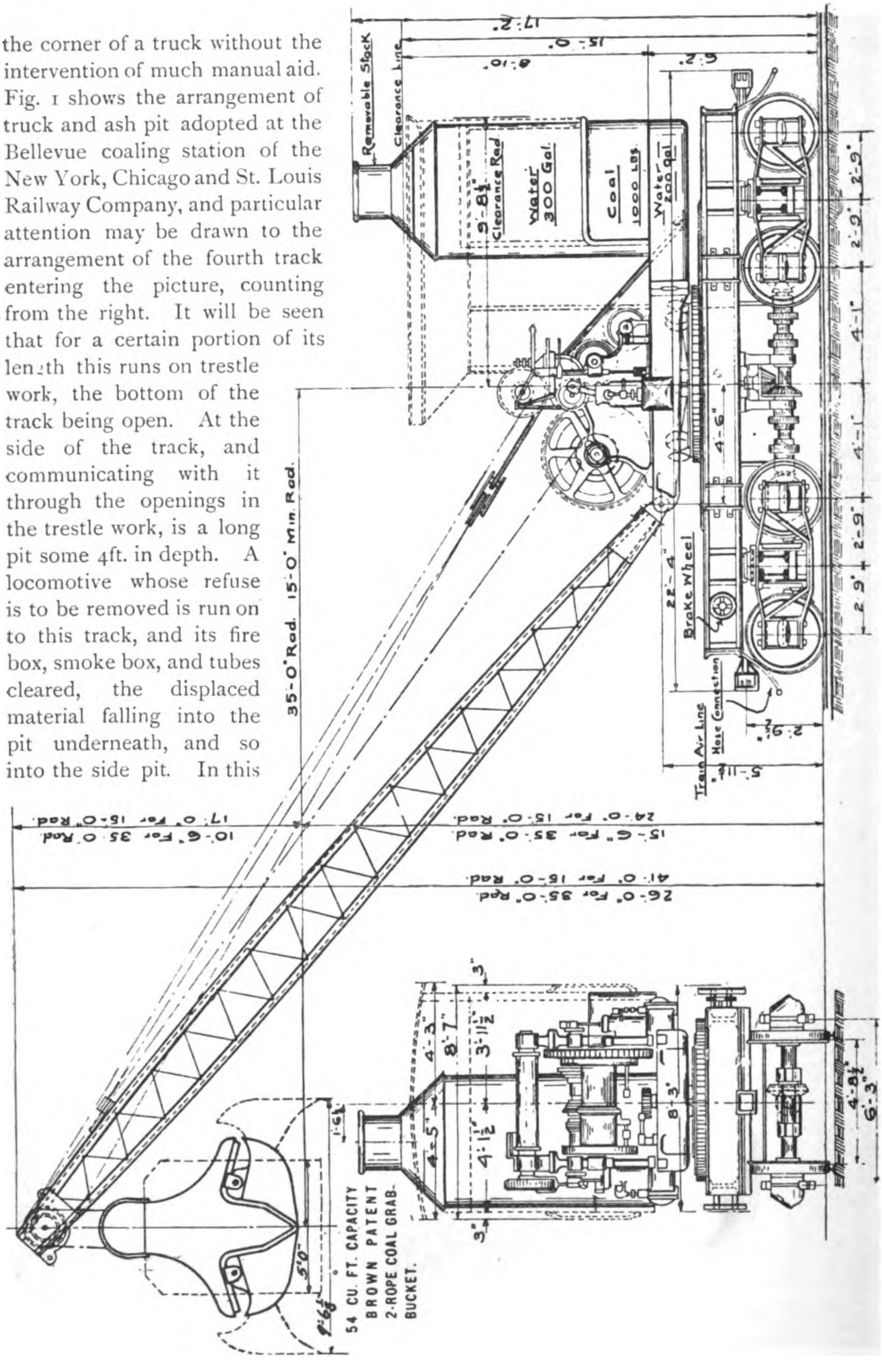

Fig. 3. The "Brownhoist" Locomotive Crane fitted with Coal Grab-bucket.

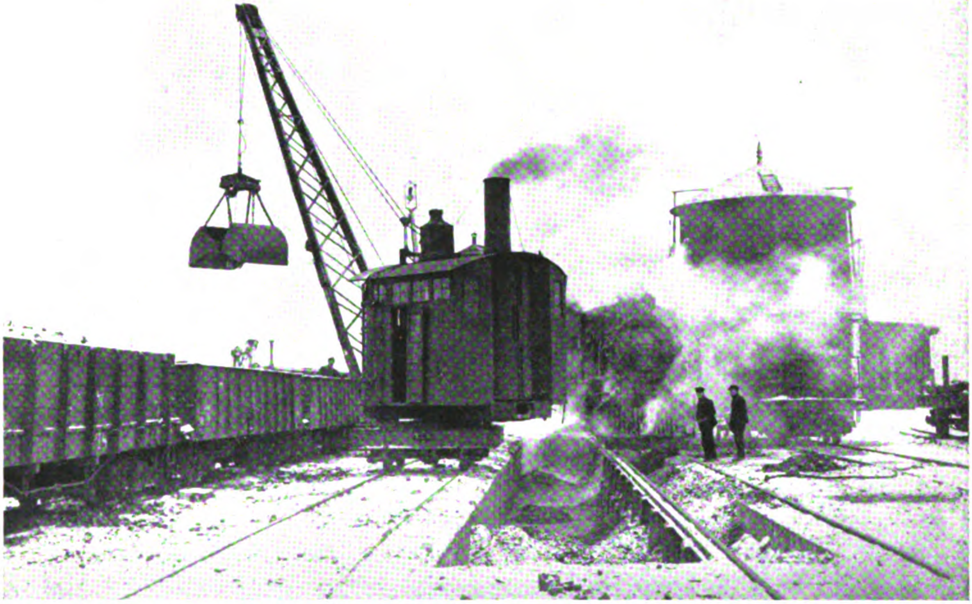

FIG. 4. LOCOMOTIVE COALING AND ASH-HANDLING PLANT. CHICAGO, BURLINGTON, AND QUINCY RAILROAD

position it is under the command of a four-wheel locomotive coaling crane, constructed by the Brown Hoisting Machinery Company, of Cleveland, which picks up the ashes and loads them into cars. Fig. 2 shows a similar arrangement at the Willson Avenue station of the Erie Railroad, Cleveland, Ohio, the "Brownhoist" crane being occupied at the moment in loading coal into the tender. The same crane also takes ashes from the pit and deposits them in cars on the adjacent tracks. Fig. 3 shows the main particulars of the eight-wheeled swivel-truck crane, equipped with the Brown coal grab bucket, which is used. The adaptation of such a system in English practice is rendered simpler by the fact that in almost every running shed the breakdown crane would be available at one time or another during the day, under normal conditions, for its use with a single rope grab in order to pick up ashes. It is always under steam and is in a clear road, and the expense of a grab attachment would be inconsiderable.

Further illustrations of this method of working are afforded by the view of a locomotive crane constructed by the Browning Engineering Company, of Cleveland, at work in the yards of the Chicago, Burlington, and Quincy Railroad at Chicago. Fig. 4 shows the arrangement of ash-pit very clearly, and indicates the manner in which the ashes when cleared from the engine fall into the space commanded by the coaling crane. It has been found that the equipment of installations of which this is a type has reduced the cost of coaling engines and cleaning ash-pits by 50 per cent. The machine, whose bucket has a capacity of one cubic yard, is capable of making fifty trips per hour swinging 180deg., and this rapidity of working has secured such consideration that the method is used on practically all the large railway systems of the United States.

As an alternative to the locomotive crane system may be mentioned the gantry crane type of gear, which the Link Belt Engineering Company, of Philadelphia, and the Chain

Belt Engineering Company, Ltd., of Derby, are developing in America and England respectively in connection with locomotive ash handling. In this instance the ash-disposal gear is a separate piece of apparatus from the coal-handling plant. The locomotive is run on to a track having beneath it a pit, as in the former case, but the rails are no longer mounted on a trestle construction. In the pits, between the metals, are tubs of the form shown in the figure, whose bodies are readily detachable from the under-frames. The bodies are of special construction, and are capable of being lifted by the pneumatic hoist spanning two lines of track. The tubs are run under the gantry carrying this hoist after the locomotive has backed out, and the hoist lifts the tub bodies off the under-frames and dumps the ashes and smudge into trucks on the adjacent track. Electricity and pressure water have also been used to operate this gear instead of compressed air, and a high speed of working is obtained, the apparatus being very cheap and effective. For most running sheds the pneumatic system is preferred, as a large proportion of the tools used in maintenance repairs are driven by compressed air.

An extension of the same idea, involving the element of storage as well as transmission, is seen in a plant erected by the same firm for the Pittsburgh and Lake Erie Rail-road at Hazelton, Ohio. This plant is shown in Fig. 5, and consists of a steel bin lined with concrete and capable of holding fifty tons of locomotive refuse. The bin is elevated as shown over five tracks of rails, the two outer ones on each side having pits underneath them, in which run tubs of the type above described. These four tracks are thus able to deal with eight locomotives at once if necessary. The central track passes between the uprights carrying the bin, and is used for the wagons which take away the ashes from the bin. The locomotives discharge the fire-box cinders and flue dust simultaneously into the tubs, which are afterwards elevated by means of two overhead trolley tracks, inclined so as to lift the tubs over the central hopper, these trolleys being driven by suitable machinery. The whole gear is operated with a minimum of hand labour.

It will be noticed that none of the equipments above described have included the use of screw, bucket, or push-plate conveyors mounted on continuous chains. These are fairly common in coal and coke handling equipments in electricity generating stations and gasworks. It has been found in such equipments that the sharp, gritty nature of the ashes and clinker causes a good deal of damage to the transmission gear, and it is possible that this is the reason why such types are not more common under the stringent conditions required by locomotive practice. Where, however, transport has to be accomplished to a storage situated at some distance from the gathering points, this is a feasibly economical arrangement, of which, however, no actual examples have as yet come under the writer's notice.

Up to the present the subject has been confined to the systems of collection and storage of the waste material; no mention has been made of its disposal. One of the most obvious suggestions is to use the material as top ballast, and this is largely done at present. Cinders from a locomotive, however, are by no means the best material possible for this purpose, on account of their friable nature. Moreover, it is inadvisable for such material, containing a fairly large proportion of sulphur, to come into contact under "weathering" conditions with iron or steel work, as the moisture of the atmosphere produces acid liquors corroding the metal in contact with them. This is especially important in view of the large use which is now being made of steel-work in bridge construction. It is true that track disposal of flue dust and the lighter particles of non-combustible material has lately been tried on some of our railways by the use of an auxiliary or alternative

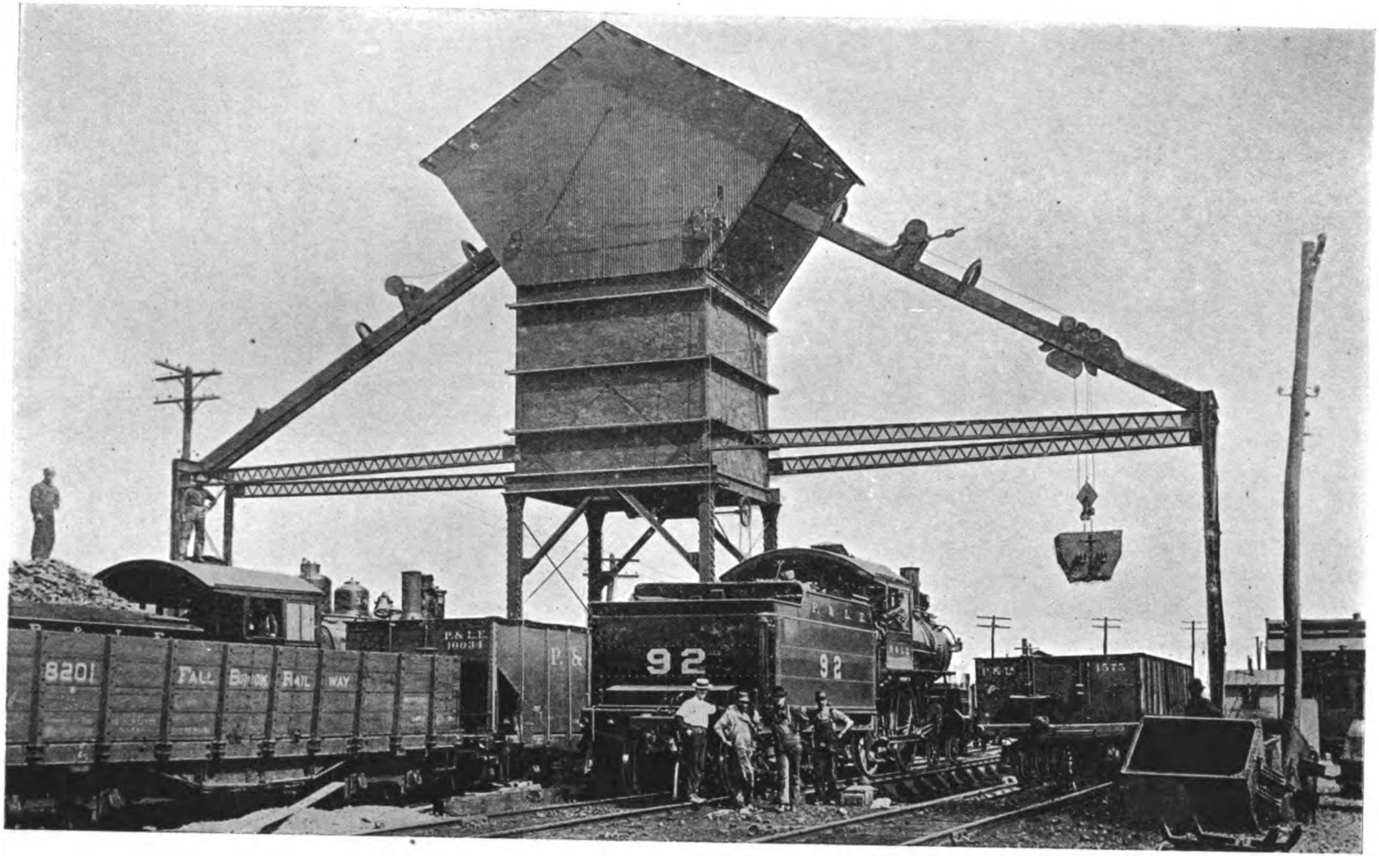

FIG. 5. ASHES-HANDLING PLANT ON THE PITTSBURG AND LAKE ERIE RAILROAD. THE TROLLEY TRACK COVERS FOUR CINDER PITS. THE LOCOMOTIVES DISCHARGE DIRECT INTO THE TUBS IN THE PIT. THE TUBS ARE LIFTED AND DISCHARGED INTO THE 50-TON CENTRE CONCRETE-LINED BIN. THE ASHES ARE TAKEN AWAY IN WAGONS PASSING THROUGH THE CENTRE UPRIGHTS. EIGHT LOCOMOTIVES USE THIS PLANT SIMULTANEOUSLY.

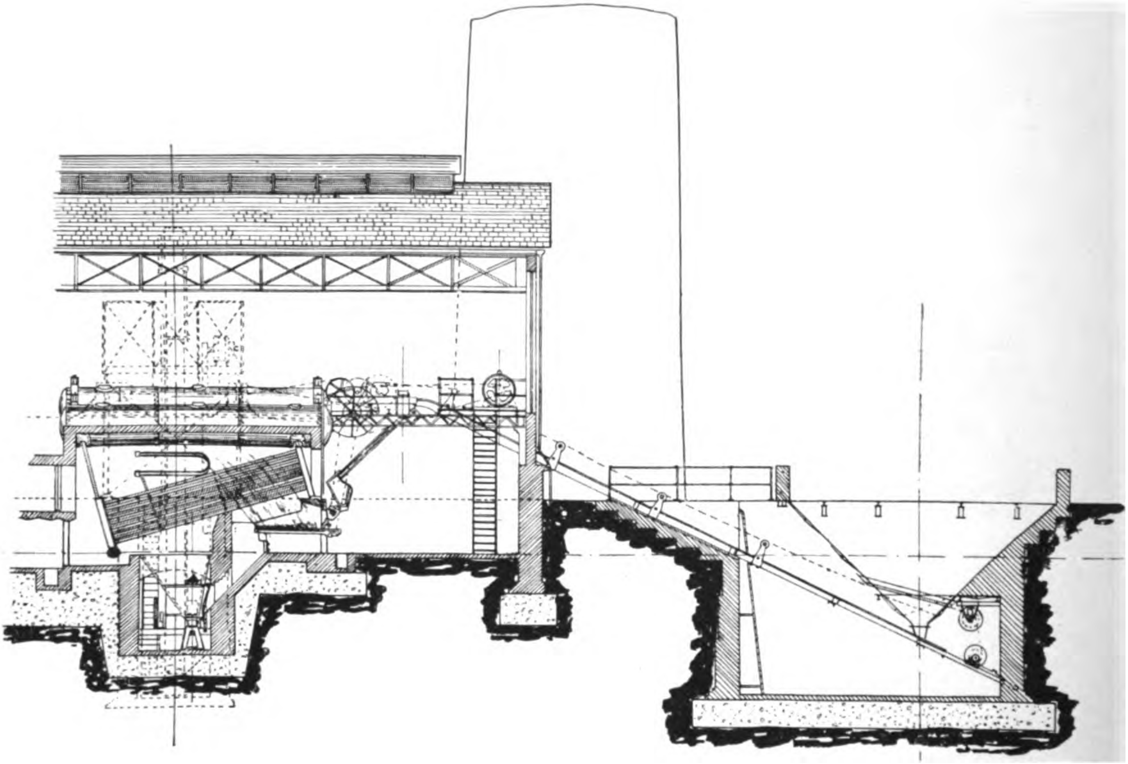

FIG. 6. BENNIS CONVEYOR PLANT FEEDING LOCOMOTIVE BREEZE TO WATER-TUBE BOILERS. PARIS-ORLEANS RAILWAY.

blast drawing the ash deposits from the surfaces of the boiler and blowing them out on to the track ; but, apart from the continuous success or non-success of this method, its use could be allowed only on lines running through open countryside, on the score of nuisance. Its adoption on such a line, for example, as the Lancashire and Yorkshire Railway, running through a succession of densely populated districts, might possibly lead to inconvenience and annoyance. The outlets for the older system of ash disposal in truckloads apart from road ballast are also rather limited as regards financial value, and it may possibly be worth suggesting that railway companies could undertake the reclaiming of waste ground adjacent to their lines, and eventually rendering it fit for building purposes, by systematic ash dumping. An ash foundation for building purposes would convert a clayey ground into a surface from which surface water would readily drain, rendering the houses especially habitable. To this end a system of light portable aerial ropeway, easily movable over a large area and radiating from a fixed charging point, is very adaptable. For the sake of example a somewhat analogous case derived from electric power house practice may be quoted. The Corporation of Sheffield have a piece of waste ground adjacent to their new power-house which is being gradually reclaimed as valuable property by the installation of an automatic aerial wire ropeway constructed on the sectional system by Messrs R. White & Sons, of Widnes, and illustrated by Fig. 7. The loading rail, situated at the point of ash discharge from the station, is connected with spans of wire arranged on a loop system

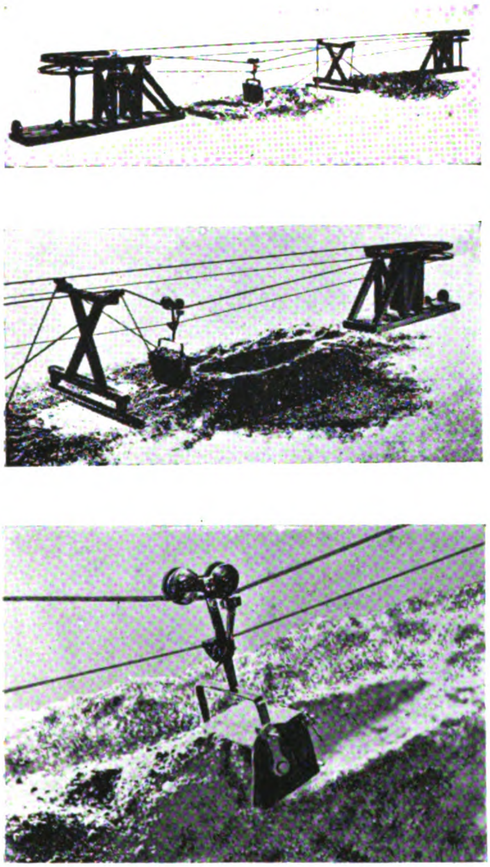

FIG. 7. AUTOMATIC SELF-FILLING, SELF-TIPPING, AND SELF-RETURN ROPEWAYS.

and carrying buckets which can be automatically tipped at any point and returned by a return and discharging terminal to the loading rail without the intervention of manual labour. The outward terminal and the span supports are so arranged that the whole gear can be moved fanwise, enabling the ashes to be spread uniformly over an area of about two acres. The system has merits which invite consideration on the part of railway engineers interested in ash disposal.

A further possibility, however, of disposal of locomotive by-products is that of the utilisation of smoke-box breeze as a fuel in specially designed furnaces. Two methods are open at the present time for this purpose. One is the consumption of the breeze in gas producers of the pressure or suction type, and at the time of writing there is evidence that at least one railway company has a producer-gas installation which is working satisfactorily by burning this breeze or "smudge," and operating gas engines from the gas so obtained. That this result has not been obtained without a considerable amount of effort and disappointment may be gauged by an examination of the fuel which is so burnt. Although it is rich in carbon, it is of a very soft, light character, liable either to bind or, if sufficient draught is obtained to produce passage of gas, to be drawn over into the scrubber. Until a little further time has elapsed, therefore, it is wiser not to lay too much stress on this particular feature.

There is, however, sufficient room for the utilisation of smoke box breeze in raising steam by means of boilers specially adapted for this class of fuel, and as an example of this may be quoted the installation fitted by Messrs. E. Bennis & Co., of Bolton, at the Ivry electricity generating station of the Paris-Orleans Railway. This generating station is used to supply energy to electric trains operating in the suburbs of Paris, and the boiler house steam raising plant consists of twelve water-tube boilers of the Babcock type, eight of which are capable of evaporating 4400lb. of water per hour each, and four evaporating 6600lb. per hour. Bennis sprinkling stokers and compressed air furnaces are fitted to each boiler, and the combined effect of the chimney draught and the pressure of air under the fire boxes is to give an equivalent draught of 1¼in. water gauge. Under these conditions a mixture of locomotive breeze and Anzin or Lievin pit coal is burnt. The amount of breeze fired into the boiler is about half the amount of slack coal. Fig. 6 shows the plant installed to feed the fuel to the boiler. To the right is seen a large dumping hopper or bin capable of holding 60 tons, over which pass two lines of railway track. The fuel from the colliery or a truck load of smoke box breeze is discharged into the bin, care being taken to discharge a truck load of each fuel simultaneously so as to mix them, the quantity of breeze being about a third that of the coal. From this hopper an elevator runs upwards at an angle of 25deg. to a second hopper which feeds a trough conveyor running parallel with the face of the boilers. The fuel is conveyed along this trough by means of an endless chain of special design, and the material is thus fed to shoots leading to the boilers, which are thus fed by gravity. At the back of the boilers, and underneath them, are a series of dust-collecting hoppers which discharge into an ash-conveyor carrying the dust and clinker to a discharge to railway waggons. The result of burning this mixture is most satisfactory, 6lb. of water being evaporated per pound of a 50 per cent. mixture of slack and breeze.

So successful has this system proved in operation that it has now been adopted in Great Britain. At the works of Messrs. Hudson, Scott & Sons, the well-known colour printers and fancy-box makers of Carlisle, Messrs. Bennis have installed a plant of stokers, furnaces, and coal-handling plant fitted to three Lancashire boilers, by means of which the smoke breeze from the locomotive sheds at Carlisle is burnt. This material costs the firm about one shilling per load, and the saving that is effected in the fuel bill can therefore be well imagined. Formerly coal costing between seven and eight shillings per ton was used, while at the present time Messrs. Hudson, Scott & Sons are obtaining all the steam they require from this locomotive smoke box breeze.

From the above notes, which must rather be regarded in the nature of suggestions than any thesis on the subject, it will at least be seen that the economical handling and disposal of locomotive engine bye-products present many lines of thought which could profitably be taken up by British railway engineers. There are no essential differences between the running practices or the fuel conditions of America or the Continent and those of our island so great as to warrant such a large variation in the treatment of these problems by us as at present exists.

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THE WORLD'S PROGRESS IN ELECTRICAL AND GENERAL ENGINEERING.

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The Board of Trade and the Brussels Exhibition.

BRITISH manufacturers should take exceptional interest in and extend their cordial support to the International and Universal Exhibition to be held in Brussels next year, for the particular reason that the Government of this country in the form of an Exhibitions Branch of the Board of Trade is available to serve their ends and assure the success of the British exhibitor. The Royal Commission appointed to take charge of the exhibitions at Brussels in 1910, and at Rome and Turin in 1911, has studied exhaustive reports of executive work in other countries, and has also been at great pains in investigating the methods pursued at previous exhibitions in which Great Britain participated.

Presided over by H.R.H. the Prince of Wales, the Royal Commission has its offices in Queen Anne's Chambers, Westminster, and the active official is Mr. U. F. Wintour, Secretary and Commissioner-General and Director of the Exhibitions Branch of the Board of Trade. This branch is to be a permanent office for the consideration of future, and revision of past, International Exhibitions in which Great Britain has been, or will be, concerned.

Every conceivable information required by proposed exhibitors can now be promptly given. The willing interest of Chambers of Commerce everywhere in the country has been attracted; while from the chief railways, steamship companies, and every important transport company, hearty assistance in the shape of cut-rates has been assured.

The report of the Committee of Investigation showed most conclusively the many causes for the disinclination to exhibit and the general lack of enthusiasm in recent years on the part of the British manufacturer for International Exhibitions. They complained of lack of organization, of isolation of exhibits, of unsuitable surroundings, of unwarrantable expense, of the necessity of costly personal supervision, of the decrease in the value of awards, and of several more defects and shortcomings which the Royal Commission will do its best to obviate, curtail, or amend, as is suitable in each case. At Brussels next year the British Government has secured perhaps the most prominent position in all the Exhibition for its section. Hitherto, owing to carelessness or tardiness, Great Britain has seen in nearly every instance all the good positions secured prior to advancing her own claims; this time the British representatives were prompt to seize on a primary choice. The British section amounts to 203,140 square feet, of which 150,640 square feet are in the Industrial Hall, and 52,500 square feet in the Machinery Hall. The amount of space covered, and certainly the positions secured, compare most favourably with the allotments to other countries. One great advantage lies in the fact that visitors must pass through the British Galleries before reaching the French, German, Italian, American and other national sections, and the old proverb of "first impressions" holds good.

The main gallery running through the British section is 510ft. long by 98ft. wide, and there are four other parallel galleries 56ft. wide, which lend themselves to the formation of attractive courts for the display of the different classes of manufactures. At the end of the main gallery, furthest from the entrance, is a double staircase leading to a bridge which gives access to the French and other foreign sections.

In the Machinery Hall the portion allotted to Great Britain occupies the centre of the Hall, and has easy access to the electric, steam, water, and gas mains, from which power can be obtained for showing all classes of machinery in motion. It is also intersected by three lines of rails which communicate directly with the Belgian State Railway system.

There will be no isolation of British exhibits ; all will be shown together, appropriately grouped and arranged under the immediate supervision of officials of the Royal Commission. All the exhibitor has to do is to purchase the space he requires and see to the transportation, for which a variety of special facilities have been secured. The principal railway companies, for instance, have agreed to accord a reduction of 50 per cent. on the usual rates for the conveyance of all unsold exhibits returned after the close of the exhibition.

The Royal Commission officials will undertake the entire handling of the exhibitors' goods within the exhibition ; not only unloading and displaying on the space reserved, but storing all empty packing cases and reloading at the close of the exhibition. With the exception of machinery and rolling stock, the exhibits of Great Britain will be grouped so as to form a complete national display of the various manufactures and products ; and with a view to uniformity, the Royal Commission will undertake the entire decoration of the British section and provide all show cases, stands, platforms and screens required by each individual exhibitor without further charge.

Every care will be taken to prevent any deprivation of individual character from the exhibits, either by too close proximity or other unharmonising causes, and if an exhibitor prefers to use his own show cases no objection will be made provided such show cases are sympathetic with the general scheme of decoration and surroundings. Designs of show cases and the proposed decorations are to be seen at the offices of the Exhibitions Branch of the Board of Trade.

In view of the great efforts which it is stated will be made by France, Germany, Italy and the United States, and certainly by Belgium itself, to give a most effective display of the most up-to-date machinery, the Royal Commission are desirous of assisting in every way to make the British machinery exhibit unrivalled. With that view the Commission will defray fifty per cent. of the charges made by the Belgian Administration for the supply of steam, gas, and electricity, when used for showing machinery producing finished articles, or illustrating a process of manufacture.

Another great convenience and saving of time and expense to machinery exhibitors has also been most thoughtfully considered by the Royal Commission. Exhibitors requiring foundations or shafting for machinery must provide them at their own cost, but can, upon sending to the offices of the Royal Commission drawings with metric measurements, have estimates obtained for them from Belgian contractors, and the work carried out under the superintendence of a competent engineer employed by the Royal Commission. No charge will be made to exhibitors for assistance rendered in this connection. Hitherto, machinery exhibitors have had to send their own constructors and engineers to superintend, frequently resulting in weeks of idle delay and unremunerative expense for expert artizans forced to await their turn. Estimates from a reliable contractor in Brussels, under the supervision of the Royal Commission, will be supplied on written request to the General Commissioner at Queen Anne's Chambers, and other estimates from equally reliable sources in Belgium can also be obtained. Crane power will be provided up to seven tons weight free of charge, and special facilities for handling heavier weights can also be secured if application be made.

A special catalogue of the British section will be made in English and French without charge to the exhibitor either for translation or insertion, and all necessary steps will be taken by the Belgian Government for the protection in Belgium of inventions, industrial designs and trade marks shown at the Exhibition.

In regard to the question of dual language, the Royal Commission specially wishes to impress upon exhibitors the desirability of having their trade catalogues and price lists translated into French. Metric equivalents of the dimensions and weights of exhibits may often be given with advantage where such information is required, and the exhibitor's agent should be in a position to quote the purchase price in Belgian currency, inclusive of freight, customs duties, and other charges. The Customs tariffs of the principal European countries will be filed in the exhibitors' reading room, together with the British commercial directories, a collection of technical dictionaries and telegraph codes.

It is of great importance that attendants be able to speak French, and other languages perhaps, fluently and technically. The Royal Commission, however, will assist matters to a great extent by providing a special apartment in which exhibitors or their agents may conduct business and deal with their correspondence. A staff of interpreters, acquainted with French, German and Italian, will also be available to afford any assistance and information that may be required.

Considering the thorough manner in which this new Government department has taken hold of the matter and the very tangible and important concessions and assistance it extends to exhibitors, it is to be hoped that our electrical and engineering manufacturers will take full advantage of the unique opportunity and combine to make the British machinery section thoroughly representative of the leading part played by this country in engineering industry and invention.

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H.M.S. "Nubian."

THE new 33-knot destroyer H.M.S. *Nubian* has completed her official speed trials and returned to the yard of her builders, Messrs. John I. Thornycroft & Co., Ltd. The vessel s performance on the trials was most satisfactory, the contract speed being greatly exceeded, and the consumption of oil fuel at full power being very low and so far the best obtained with this class of vessel.

H.M.S. *Nubian* is one of the last set of 33-knot destroyers given out to various builders last year, which comprised the *Crusader*, *Zulu*, *Maori*, and *Viking*. The *Nubian* is far ahead of her sister ships in point of time required for completion, as she is the first to carry out the official trial. It is expected that she will now be delivered and handed over complete to the Admiralty in about four weeks' time, which speaks well for Messrs. Thornycroft's capabilities for turning out work of this description quickly. It is recognised that the Woolston works are now equipped in such a manner as to be able to deal with the construction of a large number of vessels of this type in the most expeditious manner; and Messrs. Thornycroft feel confident that they are now in a position to undertake contracts for a large number of this type of vessel, and to equip and deliver them in record time should quick delivery be one of the first considerations.

The principal characteristics of H.M.S. *Nubian* are as follows :—

The vessel is 280ft. long and 26½ft. in beam, and is of about 1000 tons displacement. She has a raised forecastle which provides accommodation for the seamen, and improves the sea-going qualities of the boat, enabling her to keep the sea at high speeds in bad weather. At the after end

H.M.S. "NUBIAN."

of the forecastle deck is fitted a comfortable chart house, over which is the bridge at a considerable height above the sea level, affording good facilities for navigating and fighting the vessel. The chief officers are each provided with separate cabins, there being a commodious ward room for general use.

The ship is electrically lighted and is also fitted with a powerful searchlight in a prominent position, also a wireless telegraphy installation. The boilers are of the water-tube type and burn oil fuel, while the engines are Parsons' steam turbines, the whole of the main engines and boilers having been constructed at the Woolston works. The hull is built of high-grade steel and stiffened considerably with special transverse and longitudinal framing, and is subdivided into a number of watertight compartments by bulkheads. The steering of the ship may be performed by hand or steam gear. The armament comprises two 4in. guns and two 18in. torpedo tubes, all on deck.

It is noticeable in particular that owing to increased armament and other details the displacement of H.M.S. *Nubian* is about one hundred tons in excess of the first ship of this type built by Messrs. Thornycroft, viz., H.M.S. *Tartar*, and somewhat in excess of the last vessel of this type turned out at Woolston, viz., H.M.S. *Amazon*.

In spite of the extra load carried, the speed attained by H.M.S. *Nubian* is hardly inferior to that attained by H.M.S. *Tartar*, which still holds the record, being the speediest of her class and the fastest in the world.

Notwithstanding the great success achieved with their vessels, Messrs. Thornycroft find themselves at present with very little work in hand, and are hoping to secure further orders so as to keep their large establishment more fully employed. There has already been a large reduction in the number of hands employed, and unless the firm is able to secure new work of this description before long a further considerable reduction will have to be made.

The policy of distributing this class of work, which is highly specialised, amongst the large shipbuilding centres of the North of England, where the heavier classes of shipbuilding, such as battleships, heavy cruisers, steamship liners, &c., are built, bears very heavily on firms such as Messrs. Thornycroft, which have specialised in every department and in every way for the building of high-speed destroyers and torpedo boats. They have nothing to fall back upon if their work is given out to the larger builders, who are only willing to take this specialised class of work when they have nothing else to do. They are glad to take it at very low prices to help to maintain their establishments, covering possible loss by the profits obtained in the larger class of naval construction.

❧

Insulating Fibre.

An American engineer has recently patented a new process for the manufacture of the hard red fibre which forms one of the staple insulating materials of electrical practice. In the preparation of the fibre it is customary to treat sheets of cellulose by passing them through a strong solution of chloride of zinc, after which the sheets are piled up one on another and pressed into a homogeneous mass. The zinc chloride is then removed by washing, which is carried on in several distinct steps, as it has been found that if the material is placed directly in pure water, the osmotic pressure of the salt in the pores of the mass will draw in an excess of water and form water-blisters. On this account six weeks of washing by gradual treatment with more and more dilute solutions of the chloride is necessary for sheets of one inch or more in thickness, and this greatly increases the cost of the material when made in thick masses. The object of the patent is to improve the method of washing by utilising as a solvent for the zinc chloride a solution having such a concentration that it will have the same osmotic pressure as the zinc chloride solution to be removed. By using a solution of glycerine or glucose in water for the wash the zinc chloride can be quickly removed, the concentration of the zinc chloride is kept low, and consequently its rate of diffusion from the mass into the wash-water very high, the result being to prevent the forming of water-blisters in the fibre. An electric current may be used to increase the velocity of motion of the ions of the salt or impurity. The current causes the motion of zinc to the cathode and of chloride to the anode, and the two elements are thus separated at the electrodes. By a suitable addition of alkali and acid in dilute form to neutralise the products liberated at the electrodes and to preserve the isotonic condition of the washing liquid, the process practically amounts to the replacement of the zinc and chloride within the fibre by the components of the water, namely, H and HO ions. The two patents covering the new process contain eleven claims. One of the claims is on a process for removing a solution of metallic salt from an organic material, which consists in washing the said material with a solution relatively high in organic content and relatively low in inorganic content; and still another is on a process of removing zinc chloride from cellulose, which consists in washing said cellulose with a solution having an appreciable osmotic pressure and relatively low zinc chloride content.

❧

Tapping Machines.

Many improvements have been made from time to time by Messrs. Charles Winn & Co. in the design of screwing and tapping machines for tube works use. One of these machines is illustrated on page 23; the size shown being capable of tapping simultaneously sockets or flanges ranging from 3in. to 6in. gas sizes. As will be seen, the machine has three vertical tapping spindles, which range in power, and are geared to run at the correct speeds suited to the various size fittings—thus the centre spindle is arranged to tap 5in. and 6in. fittings, and the left and right hand the 3in. and 4in. sizes respectively.

The principal shafts and gears are carried in the upper portion of the machine, which contains all the bearings in one complete casting, thus ensuring rigidity and alignment. The drive is through fast and loose pulleys carried in a strong bracket at the right-hand side of the machine, the power being transmitted to the tapping spindles, first through a double train of gears at the side to the longitudinal shaft, and thence through steel bevel gears, which are effectively guarded, to the two vertical drum pinions which gear into the wheels upon the tapping spindles.

The machine-cut drum pinions form a very efficient method of driving the tapping spindles, and at the same time permit of their smooth vertical motion so that they can be easily raised and lowered by the hand levers, which are fitted with gun-metal slippers, and are connected by strong flat link chains to the balance weights at the back of the machine. The sockets are securely held in vices which are provided with heavy steel grips forced up by a stout square-threaded screw working in a loose renewable nut. The flanges are tapped two at one time and are held in special vices. The taps are held in plain slip-in chucks, and in operation pass right through the fittings, falling upon a strong support in the bed beneath.

A geared rotary pump is fitted on the left-hand side of the machine capable of giving a very plentiful supply of lubricant to each tap, the suds being collected for use again by a large tray provided with reservoir and strainer.

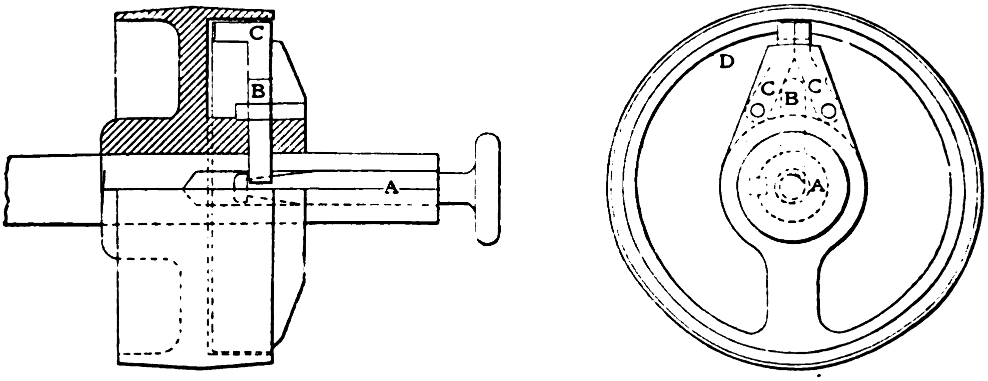
A Simple Friction Pulley.

THE sketch below shows a neat friction pulley arrangement which will probably be found of service in connection with many small electric motor installations. The design is due to a Mr. O. Johnson, correspondent of an American contemporary. It will be seen that a device of this character obviates the use of fast and loose pulleys, with the accompanying brackets, and levers of belt-shifting gear. The illustration clearly indicates the construction of the friction pulley: the tapered pin *A* is pushed in, which lifts the pin *B*, which, in turn, opens the two dogs *C* and *C'*, spreading the internal friction drum *D*. It can be seen that the clutch is self-compensating for wear, as when any of the parts wear the centre pin merely pushes in a little farther.

Twist-Drill Testing Machine.

SUCH heavy duties are nowadays required from the modern twist-drill made of high-speed steel that ordinary drilling machines are not powerful enough to test them, and special arrangements have to be made to do so by their makers. For this purpose Messrs. James Archdale & Co., Ltd., have recently finished an entirely new design of machine with extraordinary power.

This machine has been supplied to one of the chief firms of twist-drill makers solely for testing purposes. The following figures indicate its power, 40h.p. being required to obtain these results.

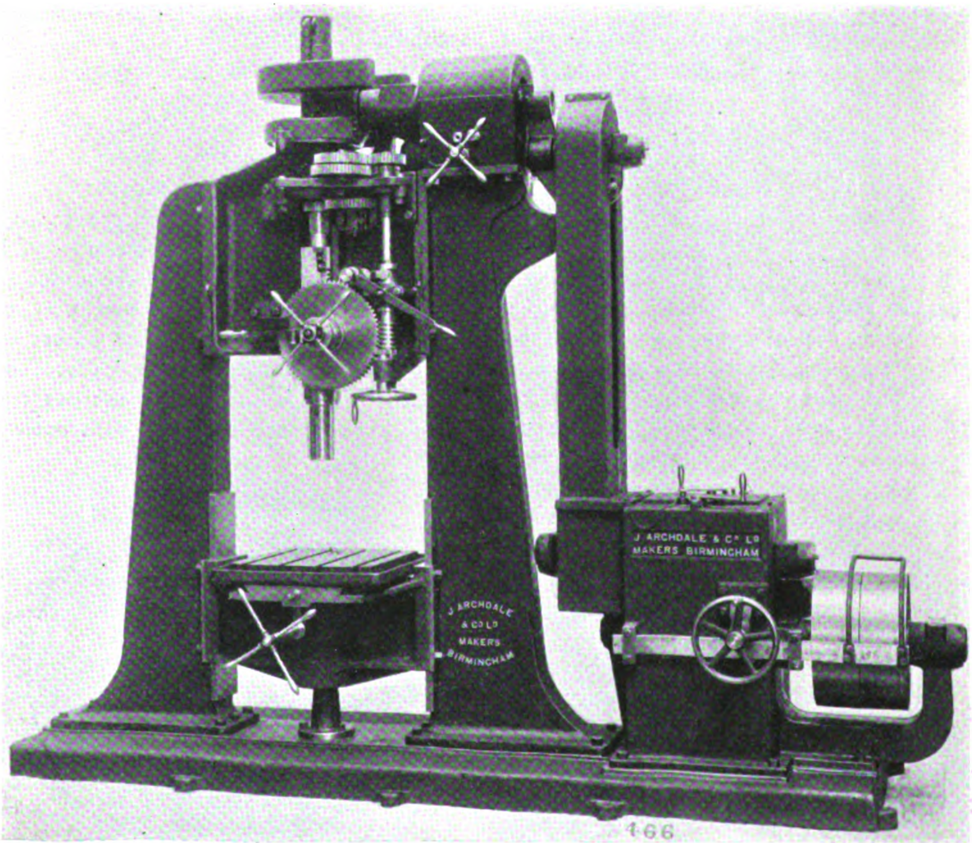


A NEW FORM OF FRICTION PULLEY.

Diam. of Drill.	Rate of Feed per Min.	
	In Mild Steel.	In Cast Iron.
1½in.	12 in.	18 in.
2 in.	7½in.	11 in.
2½in.	4½in.	7 in.
3 in.	3 in.	4½in.

The machine is specially designed and constructed with a view to great power and rigidity. The spindle is carried in a frame securely bolted between the uprights. The driving portion of the spindle is square and slides through a square hole in the driving bevel gear. The bevel pinions which drive the spindle are of forged steel and driven by spur gears carried on top of the right-hand upright, provision being made here for two changes of speed operated by sliding gears and lever. These gears are driven by means of a silent chain from a gear-box carried on the baseplate of the machine. The gear-box, which consists of sliding spur gears operated by levers, has six changes of speed, which, with the two changes mentioned above, give a total of twelve spindle speeds.

The rack sleeve is square and of hard steel bushed with bronze for the spindle bearing, and has the rack teeth cut from the solid sleeve. This feature is a very valuable one, as the feed rack has been found to be a weak place when driving drills to their limit. The thrust of the drill is taken on a ball-race,



High-Speed Twist-Drill Testing Machine.

and an automatic stop to the feed is fitted, as well as a hand clutch to enable the spindle to be moved quickly by hand.

Speed Alarm for Motor-cars.

THE notice issued by the Metropolitan Police authorities to the effect that mechanically propelled public service vehicles, including motor omnibuses and motor cabs, will shortly be required to be fitted with a device to give audible indication whenever the legal limit of speed is exceeded, has led to the design of a suitable instrument by Mr. L. H. Hounsfield. The device consists of a gong or bell mounted on some part of the car where the noise which it makes can be heard both by the driver and by persons passing. Inside the bell is a spindle running in ball bearings and driven in such a way that its speed always bears a definite relation to the speed of the car. Mounted on the spindle is a lever so pivoted as to fly outwards when the car accelerates, but restrained by a spiral spring, the tension of which can be adjusted. This pivoted lever is provided with a hammer which strikes projections on the bell and causes it to give an audible and continuous indication when the car attains a speed above the limit laid down in the regulations, and to which the restraining spring is adjusted. Damping arrangements are introduced to prevent intermittent action or hunting when near the speed limit, and to ensure a definite setting, so that the alarm can be relied upon to give warning immediately the car attains the speed limit provided for in the regulations and cease to do so when the speed falls below the limit.

The instrument is capable of adjustment so that it can be set to suit any speed of engine and size of wheel, and any speed limit which may be necessary, and when once adjusted it can be sealed by the authorities, after which its adjustments cannot possibly be interfered with without breaking the seal.

The instrument requires a simple transmission gear to communicate driving power from the cardan shaft or other part of the car. This will generally take the form of a pair of bevelled wheels, a short shaft, and a universal joint, but a flexible shaft may in some cases be more suitable. Messrs. Crompton & Co., Ltd., are the makers, and they are prepared to advise on the necessary transmission gear to suit each type of car. The new alarm has been submitted for approval to the police authorities, who have expressed themselves as being satisfied that it fulfils the required conditions.

New Electrical Instruments.

A NEW line of electrical instruments, ammeters, and voltmeters, and in switchboard and portable types, has just been placed on the market by the Weston Electrical Instrument Company.

The alternating-current ammeter and voltmeters for switchboard use shown in Figs. 1 and 2, whilst extremely reasonable in price, are claimed to embody every desirable feature for modern requirements. The makers' claims are that they have no inductance or temperature errors, that they are entirely dead beat, of permanent calibration, and have exceptionally uniform scales. Voltmeters of the type shown in Fig. 1 of ranges over 300 volts are supplied with external

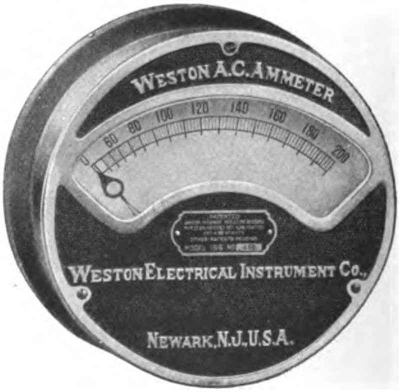


FIG. 1.

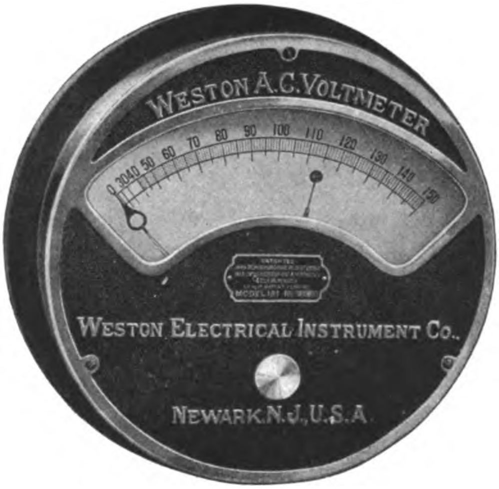


FIG. 2.

resistances; all ammeters are tested for insulation at 4600 volts for one minute, thus they are suitable for direct use on circuits of pressure up to 2300 volts. The switchboard type illustrated in Fig. 2, which has a scale length of 5.25in., as against the scale length of 6.5in. of the former type, is good for voltages up to 150 volts; above that pressure series resistances are provided.

The portable alternating-current instruments include a range of 16 ammeters, 5 mil-ammeters, and 7 voltmeters. These instruments are dead-beat and may be used on circuits of any frequency adopted in present-day engineering practice, *i.e.*, from say 15 periods to 140 periods, without sensible error in their inductions.

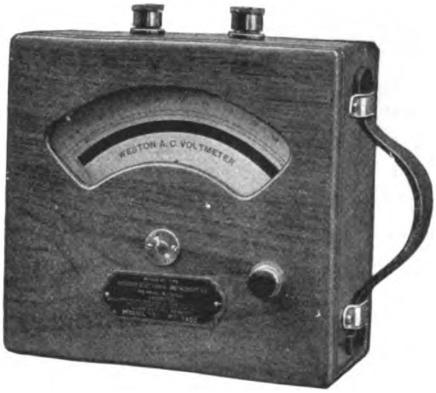


FIG. 3.

The moving system is extraordinarily light and strong, the pivots being of hardened steel accurately ground and highly polished, set in bearings of highly-finished first-quality sapphires.

The cases are of wood, neatly finished and dustproof. The instruments are very compact, light, and have excellent scales, almost absolutely proportional throughout about four-fifths of their length.

The other instruments illustrated in Figs. 5 and 6 are for switchboard use on direct-current systems. They are of the "soft-iron" or "electro-magnetic" type, but in their electrical and mechanical characteristics they are claimed to be so far in advance of all preceding forms of soft-iron instruments as to mark a new epoch in that type of instrument. Indeed they are so good as to be better than many moving-coil instruments, over which they, of course, have the further advantage of being lower in price.

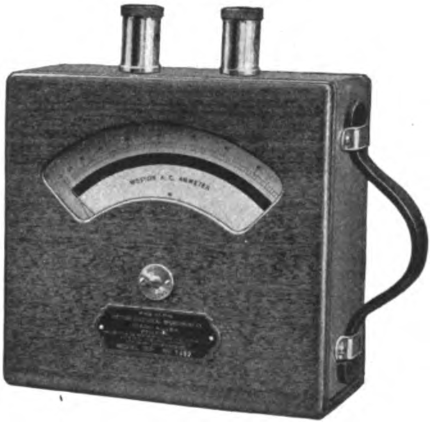


FIG. 4.

To avoid confusion with the well-known Weston permanent magnet switchboard instruments it was deemed necessary to give these soft-iron instruments a distinguishing name. They have consequently been designated "Eclipse" voltmeters and ammeters.

In the accuracy of their indications under all the widely varying conditions of practical use, they closely approach the Weston permanent magnet switchboard instruments, but, of course, have not such evenly divided scales. The scale divisions are, however, excellent for soft-iron instruments. In sensitiveness, or ability to promptly respond to minute changes in current, and in their dead beat qualities, they closely approach the Weston permanent magnet type of instrument.

The voltmeters are said to be exceptionally accurate instruments. They are permanent in calibration, independent of ordinary temperature changes, and have practically no magnetic lag, or hysteresis error, at the normal working voltage point of the different ranges, and relatively to all preceding forms, very little lag error at any point of the scale.

The ammeters have, of course, the same qualities; but we have referred to the voltmeter more particularly, because it is in the soft-iron voltmeter that the difficulties encountered are the greatest, and have heretofore been insurmountable. Indeed, it is the leading claim of the makers that these "Eclipse" instruments are so good as to warrant them being placed on the same footing as precision instruments for many practical purposes.

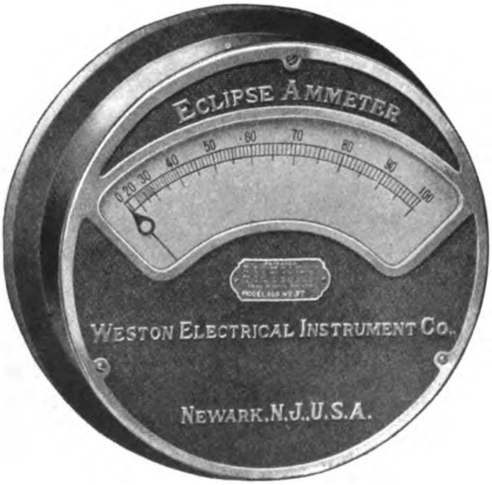


Fig. 5.

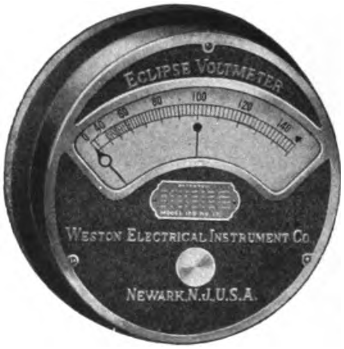


Fig. 6.

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Fire Appliances.

The old-established firm of hose makers and engineers, Messrs. F. Reddaway & Co., Ltd., has recently enlarged its works for the purpose of supplying fire brigades not only with their well-known canvas and rubber-lined hoses, but with the latest pattern fire-extinguishing apparatus. New premises have just been opened at 212, Shaftesbury Avenue, London, under the charge of Mr. F. A. Forster, who was for nearly twenty years with Messrs. Merryweather & Sons. The premises comprise a large show-room and spacious offices, and the latest fittings for public and private fire brigades, as well as the firm's hose pipes, will be shown.

The firm will also undertake the installation of fire-mains and hydrants in public buildings, hotels, mansions, &c. Most of the fire brigades of the United Kingdom have purchased Messrs. Reddaway's hose from the various fire-engine makers for whom they have in the past manufactured, and the firm will now supply these specialities direct to those wishing to purchase from the actual makers.

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THE PARIS METROPOLITAN RAILWAY.

(*Continued.*)

THE completed sections of the Metropolitan lines of Paris are taken across the Seine at three different points, upon bridges in the outlying districts and by means of the tunnel formed by metallic caissons in the heart of the town. In the case of the North-South section the line was obliged to cross underneath the Seine, as the city authorities are opposed to the erection of any more bridges in the central district. Instead of using the metallic caisson method for the construction under the river, it was decided to adopt an iron tube tunnel, which was driven through the river bed by the compressed-air method, after the usual practice for this class of tunnel. We will mention a few of the leading points about the present tunnel, which is known as the "Berlier" tube, from the fact that the original concession for the North-South line was obtained from the Prefect of the Seine and the Municipal Council by M. Berlier, a well-known civil engineer of Paris, and M. Janicot, president of the Lyons Railway and Tramways Company.

The standard double-track tunnel, after having passed through the southern half of the city, reaches a point on the bank of the Seine at which there has been built a large underground station, and the latter is made to serve as the junction point for the double-tube tunnel which runs thence under the Seine, the tubes reuniting in a similar underground station on the other bank. The two tubes start out from the masonry of the end wall of the station and run throughout their course in a direction which

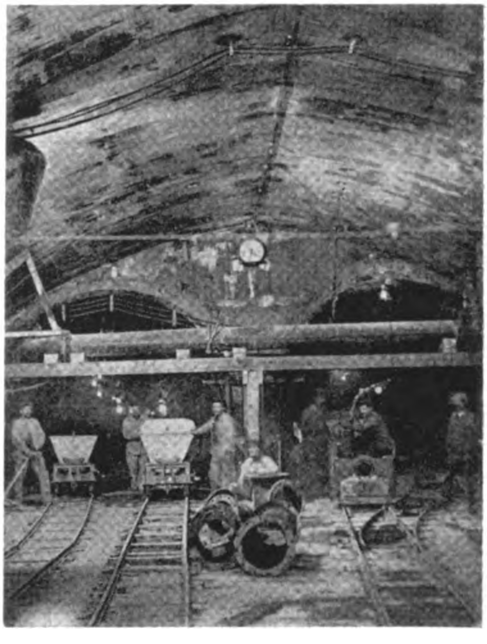


FIG. 12. WORK IN PROGRESS AT SHORE END OF TUBE SECTION.

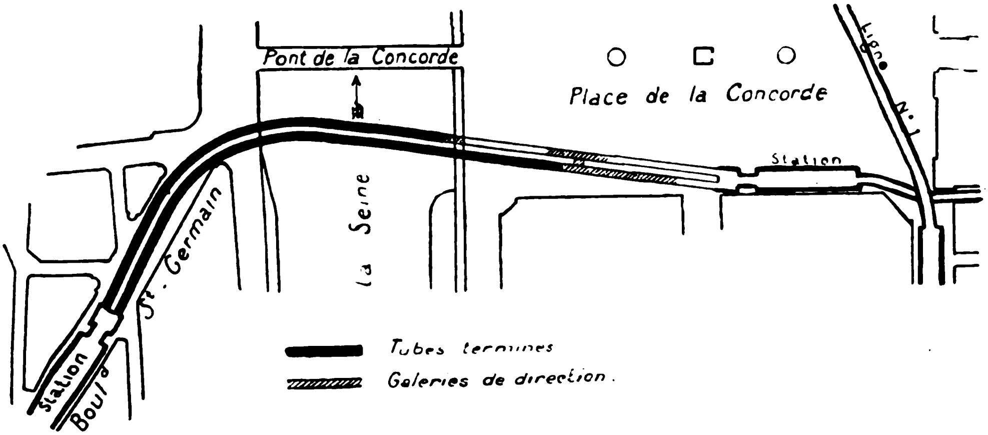


Fig. 13. Plan of the Tube Section, under the Seine, of the North-South Line.

is, generally speaking, parallel, although in fact the distance between centres of the tubes varies between 7 and 13 metres. For the entire length of the traject between the two end stations, the distance is 548 metres, but the portion lying under the Seine bed figures for less than one-third of the total, seeing that there is a long underground portion on the left bank between the station and the Seine, and a still longer one where the tunnel leaves the river and proceeds under the Place de la Concorde. This traject will be noticed in the accompanying diagram (Fig. 13).

In laying out the two tubes there are used two distinct profiles, while at the same time keeping the tubes about parallel. For the first tube which lies on the upstream, or inner, side, there is a gradient of 40 per 1000 in the portion lying under the left bank. When crossing the Seine the gradient is 1.5 per 1000, and for the section on the right bank leading to the end of the tube 35.1 per 1000. The figures for the downstream, or outer, tube are very nearly the same, these being 39, 1.5, and 34.4 per 1000 respectively. The total length of the inner tube is 538 metres, while the outer tube is 548 metres long.

Concerning the construction, the sectional view, Fig. 14, shows the tubes, each of which is designed to receive a single track of the above-mentioned standard gauge. The inside diameter of the tube is 5.00 metres, and the outside diameter 5.24 metres. It is built up in the usual way of a succession of rings which are added to the construction as the work progresses. Each of the rings is made up in turn of cast-iron segments, these latter having a developed length of 1.534 metres for the standard pattern, but for the key there is used a short segment of 0.289

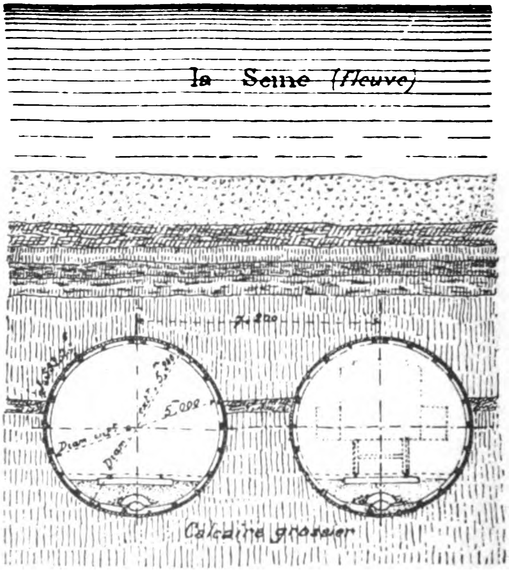


Fig. 14. Cross Section of the Tubes under the Seine.

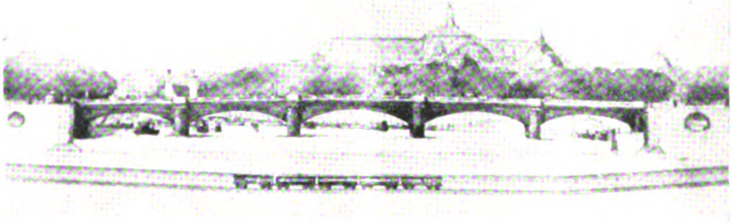


FIG. 16. THE TUBE LINE UNDER THE SEINE.

metre length. The two pieces lying adjacent to the key are 1.540 and 0.769 metres length respectively. For the joints between the segments as well as those between the rings of the tube, there is allowed a space of 0.005 metre, which is filled on the outside with strips of treated wood (poplar or pine), and on the inside with Portland cement mortar. The segments are 0.025 metre thick, and have webs of 0.095 metre height, making the total thickness to be 0.120 metre. For injecting Portland cement around the outside of the tube so as to give the filling between the earth and the tube, there are used a series of tapped holes in the segment castings of 0.030 metre diameter. By means of these holes there is injected to the outside a high grade of cement mortar by a compressing apparatus which works at a pressure of three atmospheres, after which a screw plug is placed in the hole.

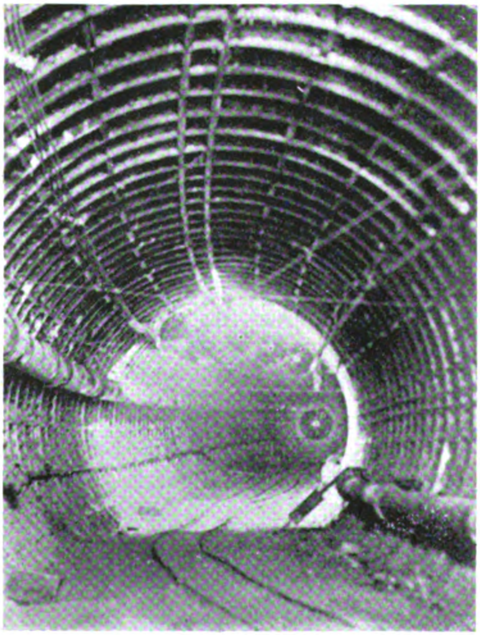


FIG. 15. THE SUB-RIVER TUBE.

The underground station at the Rue de l'Université, which serves as the starting point of the tubes, has been utilised as a power-house for the compressor plant for this part of the work. Electric motors drive a number of air compressors, the latter being driven by belt from direct-current motors.

There are two other sections of the line, which require to be taken across the river entirely in subway seeing that they cross the Seine in the central part of the town where permission could not be obtained for building bridges. Of particular interest is the metallic caisson-work which has been carried out upon the subway line which runs North and South across the city from the Clignancourt Gate to the Orleans Gate. In general, the line runs in a double-track tunnel, but at the Seine it is obliged to cross the large and the small branches of the river, and the City Island lying between the two, making a total length for the river-bed and the shore sections, in which special work, either iron tube or stations of metallic construction, is needed, to be 1903 metres, and the cost of construction for this length is no less than $3,120,000. At present this important work is nearing completion, and it is probable that the tunnel will be opened for traffic by next summer.

In the portion of the line which crosses the Seine, the iron tubular part which constitutes

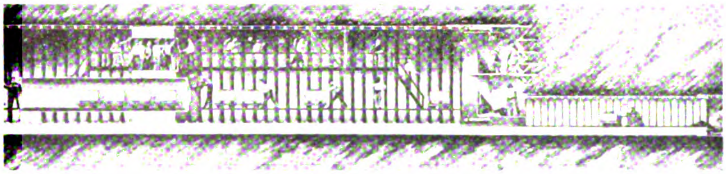


FIG. 17. UNDERGROUND WORK ON THE SHIELD SYSTEM.

the tunnel is sunk in a number of sections in the river bed by means of metallic caissons. According to this construction the tube is built into the caisson and forms the central part of it. To carry this out there is first built a skeleton iron framework which is designed to receive the tubular portion, and this latter is then bolted into place upon the framing. The tube is of somewhat elliptical section, and is designed to receive the two tracks of the line. It is made up of a series of cast-iron rings, having the standard section, and measuring 0.60 metres in width. Each of the rings in turn is built up of cast-iron segments which have a variable curvature according to the curvature of the tube, the metal being 0.030 metre thick, with strengthening ribs giving 0.160 metre thickness over all. The top of the tube is designed as a vaulting of elliptical section, and this is joined to a short straight portion at the sides. At the bottom is a circular section having 13.40 metres radius, which is joined to the sides by means of circular arcs of large radius (1.690 metre). The opening (finished) of the tunnel measured at the widest part is 7.30 metres, and the finished inside height is 5.40 metres. From the bottom of the tube to the rail-level the distance is 0.770 metre. The gauge of the track is 1.440 metre, and the tracks are spaced 1.460 metre apart.

The skeleton framework of the caisson was built at a point along the bank of the Seine where a suitable space could be found for the construction work, and the framing was assembled before the iron tube portion was put in place. This latter was only built in after the caisson had been brought to its destination farther along the river. For the caisson structure there are used a number of vertical frames made up of structural iron bent into the form which corresponds to the tunnel shape and reinforced by cross-braces. The frames are spaced 1.20 metre apart. The outer part of the framing is, however, brought down vertically at the sides in order to form a caisson which has straight sides, with a working chamber placed at the lower part. Iron plating is then riveted upon the sides, and also on the ends of the framing, and reaching nearly to the top of the latter, also upon the bottom. In this way the entire caisson has a box-shaped appearance, and can be floated along the Seine to the point where it is to be sunk. The total outside height of the caisson, including the under chamber, is thus 9.050 metres, and the chamber is 1.800 metre in height. The outside width is 9.600 metres. The iron

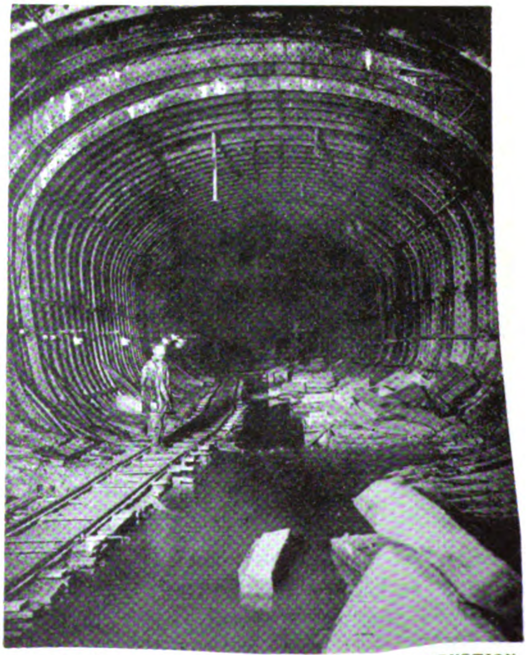


FIG. 18. THE SUB-RIVER CAISSON UNDER CONSTRUCTION.

plating on the sides and bottom is permanent, while the end plating is designed to be removed after the caissons are sunk in place so as to inter-connect them. For the framework alone constructed in this way the weight of the iron is about 280 tons.

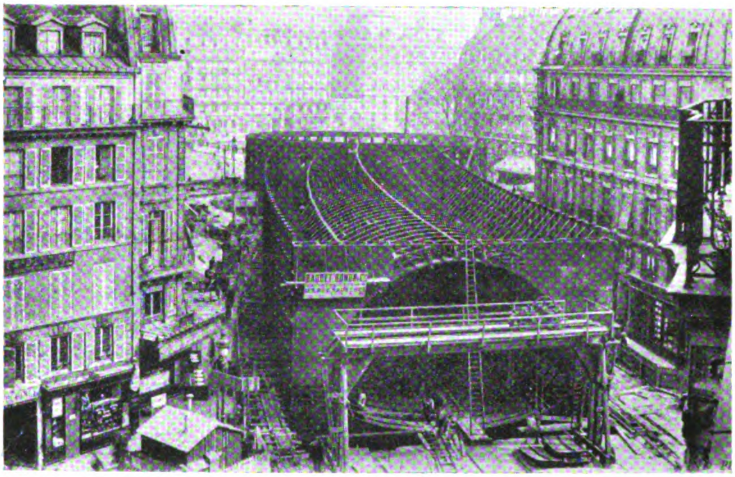


FIG. 19. END AND MIDDLE CAISSON OF STATION.

Preparatory to sinking the caissons in the river-bed at the crossing point the bed had been dredged off so as to be level, and at the same time there was built a stockade of piles which served to guide the caisson in a vertical direction during the descent. When the caisson had been brought into place, the iron tube lining was first built in. For this purpose the sections had been provided with lugs which enabled them to be held in place from the outside during the work of assemblage, thus avoiding the use of a special machine for this purpose, such as was used in the other portions of the tube tunnel outside of the caissons. When the tube had been entirely assembled beton was flowed in in order to fill up the space between the tube and the outside of the caisson, and the latter was thus made to sink down upon the river bed. After mounting the tubular shafts leading to the working chamber after the usual manner, the work of sinking the caisson down to the proper level in the river bed was begun by the compressed-air method. This latter does not present any special features. Owing to the fact that the caisson is now composed of beton, in which is embedded the structural iron framework, the whole mass gives a solid block which is practically indestructible, and offers a high resistance to deformation.

In the large arm of the Seine there are sunk three caissons of the above construction, these having varying lengths of 36.0, 38.4 and 43.2 metres respectively. As this part of the traject is laid out in a curve having 350 metres radius, the caissons are built according to this curve. For the short arm of the Seine are employed two caissons which are of a straight construction in this part of the line, and each of them measures 19.8 metres long. In order to allow for any variation in position during the descent, there is given a space of 1.5 metre between the ends of the caissons, and this interval is afterwards filled up by a beton and masonry construction which is built in place by means of a system of special caissons of small size. By means of this construction and the removal of the iron plating on the ends, we have a continuous tunnel under the Seine. Upon this portion of the subway there were required to be constructed two underground stations; but as one of these is located in the City Island and the second at Place St. Michel on the left bank and in proximity to the river, it was not possible to build the stations by the ordinary means on account of the nature of the soil. For this reason the metallic caisson system was required to be adopted for the stations also, and as these latter are of a large size the present work presents the larger piece of caisson construction which has been done on the Continent in connection with subway work.

The construction at the Place St. Michel is shown in the different views which appeared in the first part of this article. As a whole, the underground station is built in three separate parts, each of these requiring a separate caisson. The central portion is used to contain the double tracks and a station platform lying on each side of the latter. Each of the end portions is used to afford the necessary access to the platforms by means of staircases and elevators, and also contains the ticket office, &c. The method of using three separate caissons was adopted from the fact that a single caisson taking in the whole station would be far too large to be constructed and sunk, and even in the present case the middle caisson is a very large piece of work.

As regards the construction of the central caisson it is made up somewhat like the river caissons, but of much larger size, containing a tubular portion which is built inside of a supporting frame of structural iron, the latter being made up of a series of trusses. The tunnel portion is laid out with a vault of circular section having 6.25 metres radius while the invert is of elliptical section and is joined to the latter by short circular arcs. The inside opening is 13.5 metres and the total height 8.40 metres, with 1.05 metre from the bottom point to the rail level. For the station platforms, the width is reduced to 3.5 metres. The width of the truss frame measured vertically at the height of the vault is 1.00 metre. Including the working chamber, the total height of the caisson is 12.50 metres, and its length 66.0 metres, and width 16.5 metres. The truss frames are spaced 1.3 metre apart, and are connected together by a framing of cross-braces. Instead of cast-iron sections, as were used in the river caissons, the tubular portion is formed of a lining of plate-iron, of 0.008 metre thickness, which is riveted to the iron supporting frame. The present section is, however, the one which is used in the City Island station, and here the outside plating of the caisson is made to follow around the curved top of the framing. Another method is employed for the Place St. Michel station, where there is added to the arched portion a set of vertical supports so as to make up a side framework which runs up to a height somewhat above the top of the arched portion. On the vertical framing is laid the iron plating, so that it forms a caisson with straight sides. This was done in order to prevent the falling in of the ground during the

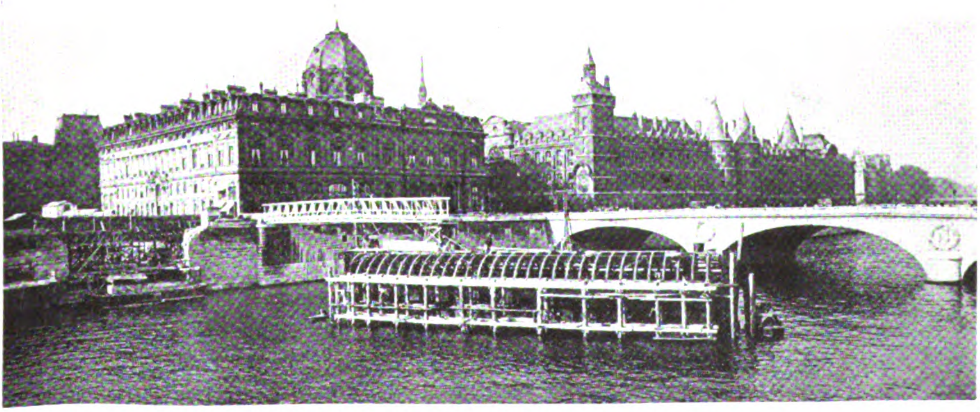


FIG. 20. VIEW OF CAISSON ON THE SEINE BEFORE SUBMERSION.

descent of the caisson, seeing that the houses of the square are in close proximity to it, and any movement of the ground might cause much damage to the property. The caisson now fits exactly into the trench during the sinking, and it has another advantage in being well guided during the operation, which is a somewhat difficult one owing to the great weight of the mass. For the same reason the working chamber is separated into four independent compartments by longitudinal and cross partitions, as this will give a much better balance during the sinking than could be obtained with a single large chamber. The Place St. Michel caisson is built on a 330 metre radius, while that of the City Island has a 640 metre radius.

As the soil is dry down to a certain point, the caisson could be built in an open trench at a depth of 3 metres. After finishing the iron work, the structure was weighted by filling in beton between the tubular part and the outer walls. During the first part of the sinking the total weight which was thus obtained was 12,000 tons, but in order to give a sufficient weight to lower it down to the required depth of 20 metres below ground level, or 15 metres below the normal level of the Seine, it was required to load it with an additional amount of earth and sand, so that when it reached the bottom the weight was no less than 18,000 tons.

Quite another construction is used for the end caissons, and these are also of large size. At each end there is a similar structure which is designed to form a shaft or well of elliptical section. The caisson is built so as to have two concentric iron platings between which beton is filled in so as to give solid walls for the structure. To hold the plating there was first built a skeleton frame of vertical supporting frames spaced around the ellipse, and these supports were braced together by connecting pieces. Between the inner and the outer plating there was thus a space of 1.50 metre, which contains 2500 tons of beton, and the whole makes up a solid mass. Upon the bottom is constructed a working chamber in the usual way. The larger axis of the ellipse, measured at the outside of the structure, is 99 metres, and it lies across the direction of the tracks, while the smaller axis is 82 metres. The total height of the caisson is 76 metres. On the top is laid a strong flooring of steel beams and masonry which is designed to support the street paving at this point, and the top of the finished structure comes within one metre of the street level. Counting 650 tons of structural iron and 2500 tons of beton, the weight of the end caisson is 3150 tons. For the three caissons of the station we thus have the considerable weight of 17,300 tons of iron and beton. There is left a space of 1.5 metre between the caissons, and they are joined together when in place in about the same way as for the river caissons. The total length of the station, comprising the three caissons, is 118 metres.

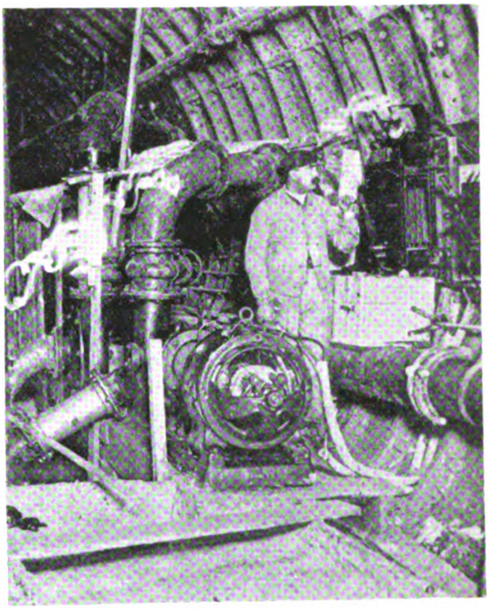


FIG. 21. ELECTRIC PUMPING PLANT IN TUBE.

For connecting the two underground stations with the river tunnel there are used short sections of iron tube tunnel, which are run by means of the compressed-air shield.

The machines, which are installed at this point, have a total capacity of 1300h.p., and include four air-compressors for the work in the two tubes, and two batteries of pumps for the water supply needed for operating the hydraulic jacks. A gallery of 234 metres length runs from the underground station, and a stockade which is built along the Seine near the working point. Small cars thus take out the earth from the tunnel, and this is dumped into the river barges. In like manner the castings of the tube and other material are taken in for the construction. Electric tractors equipped on the trolley system are used for hauling the trains of cars for this purpose. Since the upstream tube of the North-South line has entered under the Place de la Concorde, the compressed-air work has been discontinued, and the work is now carried on in free air. The other tube is still working with compressed air. At present the tubes are advancing at the average rate of 6ft. per day, counting for the time taken in making the injections of cement.

The report for the year 1908 of the directors of the company, recently published, is of value as showing the commercial results obtained on the completed sections up to date. The length of line open to traffic increased from 28 miles at the beginning of the year to 32 miles on April 21st, and this mileage remained unchanged during the rest of the year. The accounts for the past two years include the following items:—

	1908.	1907.
Share capital	£3,000,000	£3,000,000
Bond capital	1,890,000	1,890,000
Total receipts	1,626,400	1,387,200
Working expenses	683,400	598,200
Municipal share in gross receipts	530,700	449,000
Net profits	357,500	340,000
Dividend, per cent.	8	7⅜
Number of tickets issued ..	229,700,519	194,823,282

The company's rolling stock at the end of 1908 comprised 488 motor-coaches and 463 trailers, as compared with 365 and 415 respectively at the close of 1907, and an additional 128 motor-coaches and 74 trailers have been ordered and are in course of construction. All grades of employés increased from 3,630 on December 31st, 1907, to 4,114 on the same date in 1908, and the system of granting bonuses to the various classes for the good management of the railway was maintained and developed during the year. The amount paid in this way was £19,800, or £3,320 in excess of that devoted to the same purpose in 1907. In addition to this, the company continued to interest itself in the building of workmen's dwellings for its employés, and at the end of 1908 the total advances reached £19,200, allowing for the erection of 76 houses. The money is lent to the staff and workmen, partly at the rate of 2½ per cent. with repayment to take place in 12 years, and partly at 3 per cent. with redemption in 20 years.

Other parts of the report deal with the progress made towards the completion of the system and the perfecting of the tunnel ventilation, station approaches, &c. Regarding the matter of ventilation it was found that fans had not given the results anticipated, whereas the building of bays off the tunnels had proved effective both as a means of ventilation and as a source of light. Mechanical stairways and lifts are both being tried at stations. It is anticipated that the North-South transverse section of the system and the second network will be completed and put into operation next year. The third network will not be completed before 1911, although the work is being pushed forward as rapidly as possible. The system is very popular and its success is assured.

* * *

MILLING AND MILLING CUTTERS.

ALTHOUGH the milling machine has become tremendously popular with engineers in all branches of machine manufacture there are still many establishments in which these machines are operated inefficiently and very much below their maximum output.

The early milling machine had a very limited field of work. In 1850 milling was substituted for hand labour in the manufacture of small arms, sewing machine parts, &c., and for many years following that milling was only considered suitable for producing small objects of special shape. In those days the machine found very little favour for general work owing to the cost of the cutters, which were then cut and re-sharpened by hand. With the advent and subsequent development of the cutter grinding machine, whereby cutters could be readily sharpened without softening the cutter, the reputation of the milling machine as a metal removing medium began to spread until the process of milling has become indispensable on many classes of work in most branches of machine manufacture. In old established industries, however, there is still much conservatism as regards the manipulation of the milling machine, and no doubt much of this, especially with regard to rate of feed, design of cutters, &c., is in part due to the recollection of the old-time machine with its costly equipment and limited rate of output.

In this strenuous profit-making age every engineer is anxious to obtain the greatest possible output combined with accuracy and finish sufficient for his requirements. To attain these ends it is necessary to give attention to certain factors which influence the amount and quality of the work.

The principal factors governing the output when performing milling operations are:—

1. Those which may be directly assigned to the machine itself or its component parts.

2. Those which are due to the nature, form, or condition of the objects or material operated upon.

3. Those which are dependent on the design of the equipment, together with intelligence and discrimination on the part of the operator and his superiors. The various factors coming under these headings will now be considered seriatim.

The Machine. — The requirements with reference to the machine itself are as follows:—Sufficient available power at each spindle speed for the range of work to be dealt with. The component parts should be sufficiently strong to utilise the whole of the power provided without chatter; in other words, the machine should be correctly proportioned, the problem being that of correct distribution of metal without unnecessary weight in parts.

The Work.—Limitations of output under this heading may be due to hard castings, and many firms find it beneficial to pickle or anneal the castings previous to milling operations,

The modern air hardening steels have done much to eliminate difficulties when operating on specially flinty materials, and a maximum output is ensured by the use of a cutter of suitable steel and running it to its utmost capacity of rate of speed and feed, as far as the stiffness of the machine and work will allow.

The form of the work constitutes an unavoidable source of trouble in many cases, frail castings causing chatter and spring in the work. Another important factor under

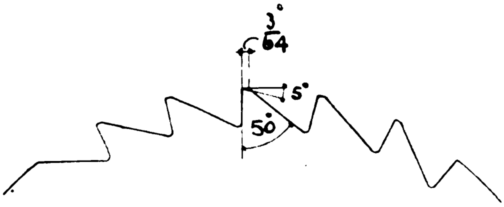


Fig. 1. Form of Milling Cutter Tooth.

this heading is that of accurate moulding and pattern making on repetition work. The castings are usually located from their rough surfaces, and much expense in the milling department is often caused by inaccurate moulding and bad casting.

Equipment and Operation.—The form and condition of the cutter play a very important part in milling. The design of cutters should be entrusted to a skilled specialist in order to obtain the best results, and on repetition work it is necessary to keep records of feeds, speeds, &c., relating to the various jobs dealt with. It very often happens that jobs are set up by irresponsible persons, and apparently giving satisfaction, when a slight alteration in the cutter speed or feed would result in a much greater output. Another essential feature in productive engineering is the use of suitable jigs and fixtures which should be constructed in order to reduce to a minimum the amount of time required to fix and locate the work. The initial cost of such appliances very often presents a problem in manufacturing, but it frequently happens that such costs are repaid over and over again by reason of the great economies effected by their use. No hard and fast rule can be stated as to when jigs and fixtures should be made, this question depending largely on the number of pieces which are to be made and incidentally on changes in form of models, various odd sizes, &c.

From the foregoing it will be seen that most of the vital factors influencing the output with milling operations are largely dependent on the discrimination and intelligence displayed on the part of the operator and works staff.

There are many excellent types of milling machines on the market, which fulfil most of the requirements, and it is the writer's belief that the factors coming under headings two and three have more influence on the rate of output and quality of the work than any of the shortcomings of the commercial milling machine. With the object of pointing out some of the most important features in milling cutters, the design and manufacture of a few common types of milling cutters will next be considered.

In large manufacturing establishments dealing with an extensive range of work, the upkeep of tools for the milling department is naturally a costly item, and with a view to

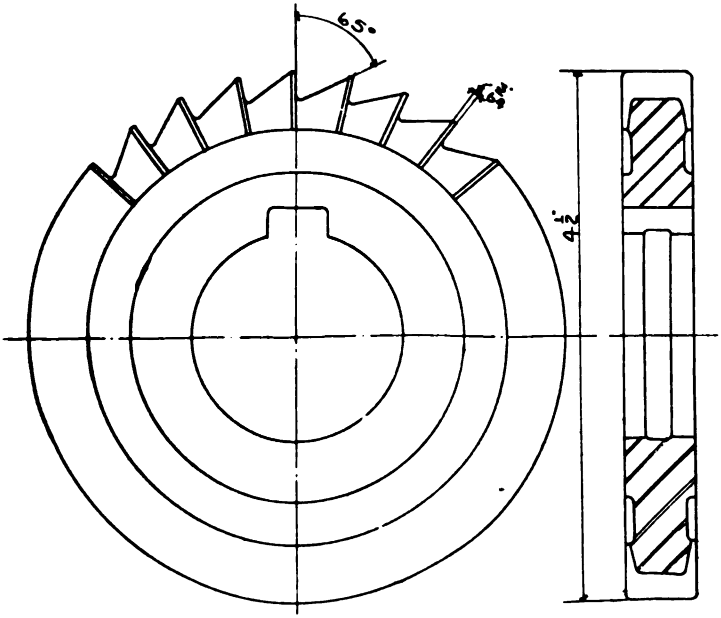


Fig. 2. Side and Face Milling Cutter.

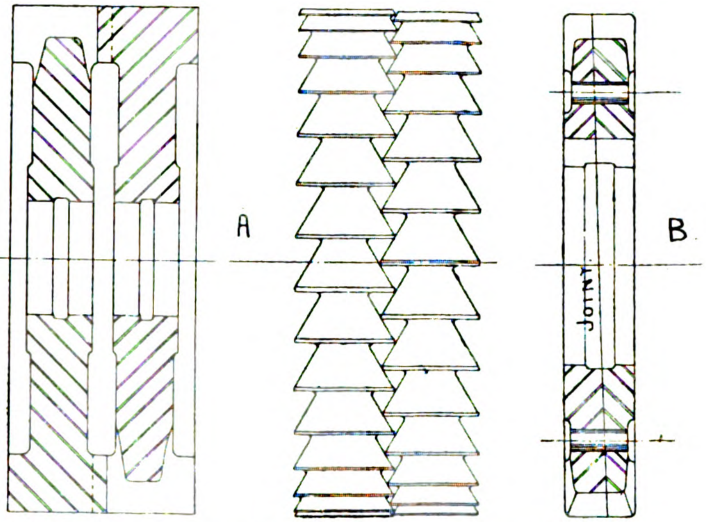


FIG. 4. INTERLOCKING AND SPLIT SIDE AND FACE CUTTERS TO MAINTAIN A STANDARD WIDTH OF SLOT.

keeping down capital expenditure, the cutters and arbors are manufactured so as to be interchangeable on the different machines in operation. Small cutters require no driving key, the cutter being held firmly enough by friction for the slight resistance the work offers. With the medium and larger sizes of cutter, two or three different sizes of arbor and keys may suffice for the work, so as to ensure having the least possible number of sizes and variety of arbor. The cutters should be standardised as far as possible so as to simplify the work of the tool room, and each cutter should be stamped with the outside diameter, width, bore, and material, for future reference when the cutters require renewing. The cutter blank is first bored and turned to the required form and size, the bore being chambered so as to leave two narrow strips, so that the hole may be readily ground to fit the cutter arbor; similar faces are left on the ends in order to facilitate grinding to fit collars and packing pieces.

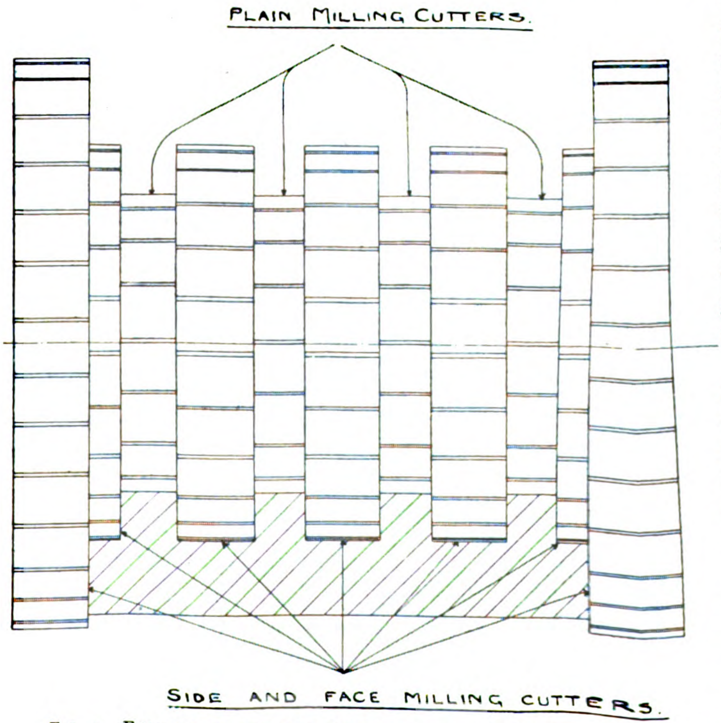


FIG. 3. EXAMPLE OF THE CLASS OF WORK UPON WHICH SIDE AND FACE CUTTERS ARE CHIEFLY EMPLOYED.

The diameter and sides are left .015in. full, so as to permit of grinding to size after hardening. The bore is treated in a like fashion, the hole being left .015in. small for sizes of 1in. and over, whilst the smaller sizes are left .003in. to .005in. small to be lapped out to size.

An excellent plan is to have snap gauges, one side of which is .015in. under

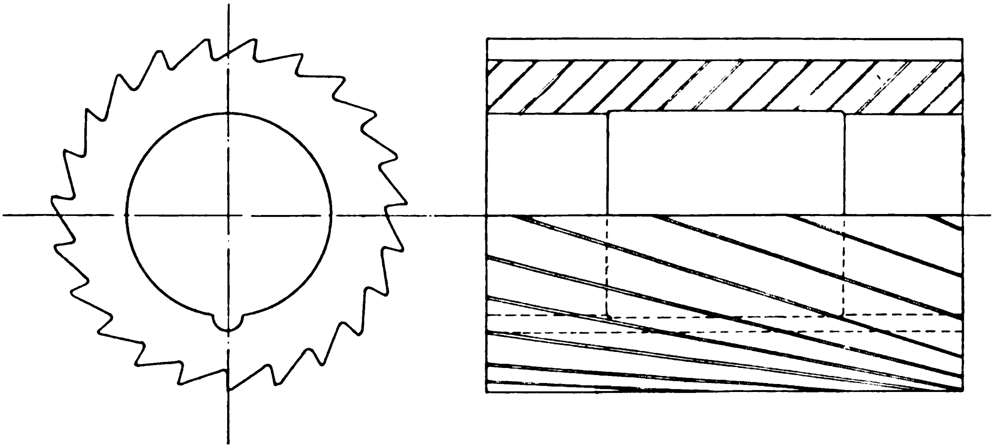


FIG. 5. PLAIN MILLING CUTTER WITH SPIRAL TEETH.

size, and the other opened out to the standard size, the two ends being marked "before hardening" and "after hardening" respectively. The arrangement eliminates time lost in applying rule or micrometer in working to size for widths.

Special mandrils are also required for cutter-making. The ordinary standard size mandrils having a taper of say .001in. per inch, it will be obvious that they are unsuitable for the odd sizes of the cutter bore before hardening.

For heating the cutter previous to tempering, a gas meter is required preferably with pyrometer regulation. Tempering the cutter is either performed by placing in an oil bath, composition bath, or air blast, according to the nature of the steel used. The process of hardening and tempering cannot be too carefully carried out, and here again it is extremely important that observations should be intelligently made with the object of obtaining the best possible results with all forms of cutters and the various kinds of steel used.

With the modern appliances now in vogue many of the former difficulties incidental to hardening of cutters have been removed, but there are still many kinks and dodges to be resorted to in hardening which are only acquired by long practice on that class of work.

Experience and modern tendency go to show that milling cutters should have a coarse pitch of tooth. The old practice was that of a great number of teeth which scraped rather than cut the material operated upon. Fine teeth clog with the chips, and the excessive friction and rubbing action rapidly destroys the cutting edges and limits the output to a very great extent. Now a milling cutter will do more work and do it more efficiently if the pitch permits of each tooth getting well under the surface, and in order to show in what way the feed per tooth is affected by their number, it will be necessary to examine their action when in operation.

The action of each tooth of a side cutter when milling is as follows:—In one complete turn of the cutter a certain amount of metal is displaced; the cut taken by each tooth commences at zero, and increases to a maximum at the point where the cutter leaves the work, each tooth taking its share of the total amount removed per turn of the cutter. From this it will be obvious that, given a certain feed per revolution of the cutter, the cut per tooth will vary with the number of teeth in the cutter; in other words, the greater the number of teeth the finer will be the feed per tooth, *i.e.*—

$$\text{Feed per tooth} = \frac{\text{Feed per turn}}{\text{Number of teeth}}$$

This feed per tooth can be conveniently adopted as a base to work upon when setting up work. For example, if a certain feed per tooth has been found satisfactory when operating on a given material, with a certain cutter, then the feed of a different size of cutter, or that of a cutter with a different number of teeth, can be adjusted to give the same rate of feed per tooth in order to obtain the correct rate of output. The following table represents the writer's practice for general use with reference to the number of teeth for solid milling cutters.

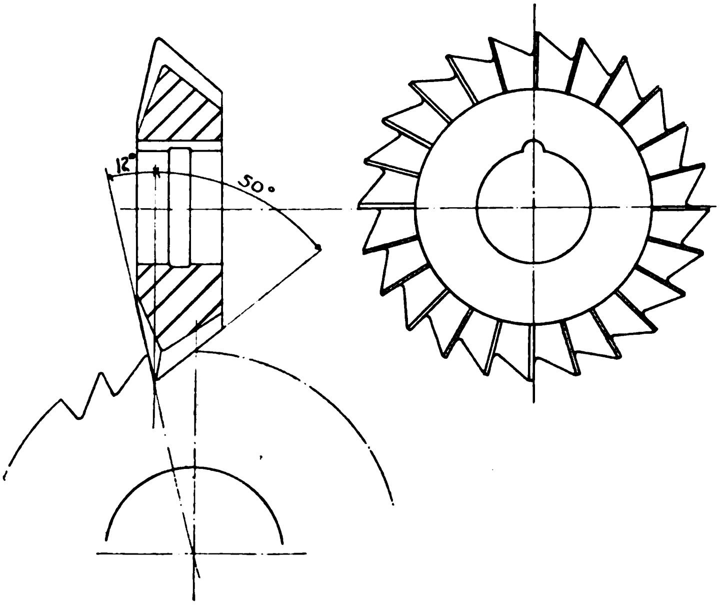


FIG. 6. SPECIAL DOUBLE-ANGLE CUTTER FOR CUTTING SPIRAL TEETH.

Diameter of cutter in inches.	Number of teeth.
½	8
¾	10
1	10
1¼	12
1½	12
1¾	14
2	14
2½	16
3	16
3½	20
4	20
4½	24
5	24
5½	24
6	24

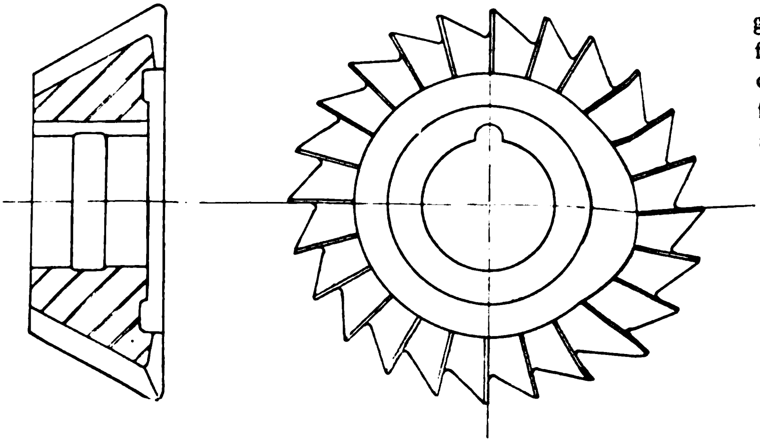


FIG. 7. ANGULAR MILLING CUTTER.

Angle of tooth.—For general work the front faces of the teeth are cut radially, with no front rake. The spaces are formed with a cutter selected, so as to leave an angle of 50deg. to 55deg., see Fig. 1. The bottom of the tooth should be left well rounded for stiffness, and to avoid cracking in hardening.

The tooth should be ground so as to leave

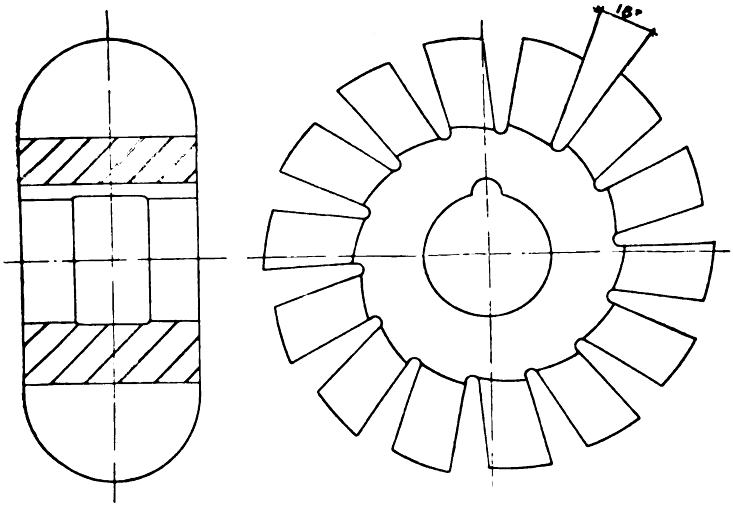


FIG. 8. FORMED MILLING CUTTER.

a clearance angle of about 5deg., and the width at the top of tooth should be left from 0.04in. to 0.09in. wide so as to furnish well supported cutting edges.

Side and end teeth may be left with a larger and consequently stiffer angle, since these teeth do less work and require less grinding than those on the periphery. For forming the spaces for side and end teeth a 70deg. to 75deg. cutter is usually employed, leaving a similar angle of tooth; the index head of the machine being thrown over so as to leave a constant width of tooth along the top of the cutting edge.

Side and Face Cutters.—The side and face cutter (Fig. 2) is chiefly used for milling grooves, slots, keyways, and the sides and ends of work (see Fig. 3). The side teeth provide space and clearance for chips where a plain cylindrical cutter would choke and leave rough.

This class of work crops up very frequently when manufacturing interchangeable machine parts, and when working to gauge with a small variation allowance, the chief difficulty is that owing to wear and regrinding, the cutters soon lose their width, and some means of maintaining a standard width of cutter has to be resorted to. Fig. 4 shows methods of overcoming this difficulty. A shows two cutters arranged so as to interlock, with the object of leaving no line or fin on the surface of the work at the joint of the cutters; as the cutters decrease in width the correct size is maintained by the introduction of paper packing or a different size of distance collar. Another form of adjustable cutter is shown at B. In this case the cutter is split; the joint is inclined to the axis of the cutter in order to avoid marking the work. Paper rings are inserted as in the last case, to compensate for the loss of width.

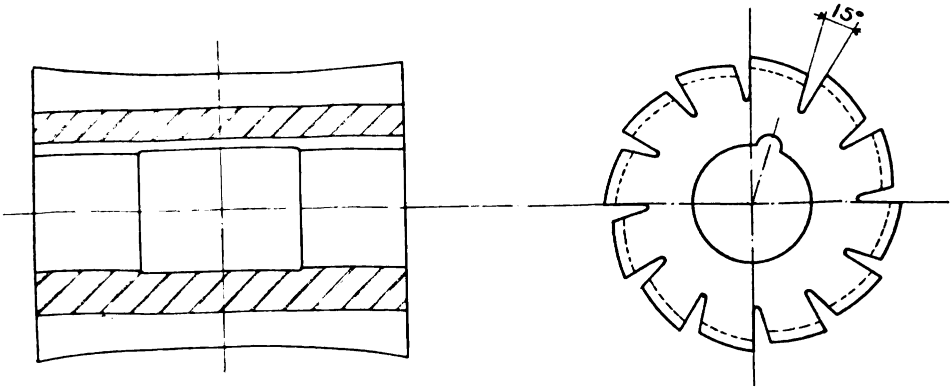


FIG. 9. FORMED MILLING CUTTER.

Plain Milling Cutters.—Fig. 5 shows the plain milling cutter, which is so called by reason of having teeth on the circumference only, the end faces being left plain. Plain cutters of any considerable width, if left with straight teeth, cut in a very choppy fashion. Especially is this the case on shallow cuts with only one or two teeth simultaneously in action; each tooth takes a very wide cut, and the great pressure required to remove the metal very often causes a great amount of spring and chatter in the machine parts and the work, and interferes considerably with the quality and finish of the work. The spiral tooth ensures a smooth shearing action when cutting, and considerably reduces the turning effort against a given cut. For the reason stated above it is usual to make all plain milling cutters, say, over 1in. wide with spiral teeth.

On heavy work the cutters are notched or nicked by a series of breaks in the cutting edges, these breaks running in a coarse spiral from end to end of the cutter. The notches break up the chips and permit of heavier cuts being taken than would be possible with an unbroken cutting edge. For general work an angle of spiral of 27½deg. with the axis of the cutter gives very good results. For cutting helical teeth, the data required for milling are the lead of the spiral and the angle of the tooth with the axis of the cutter.

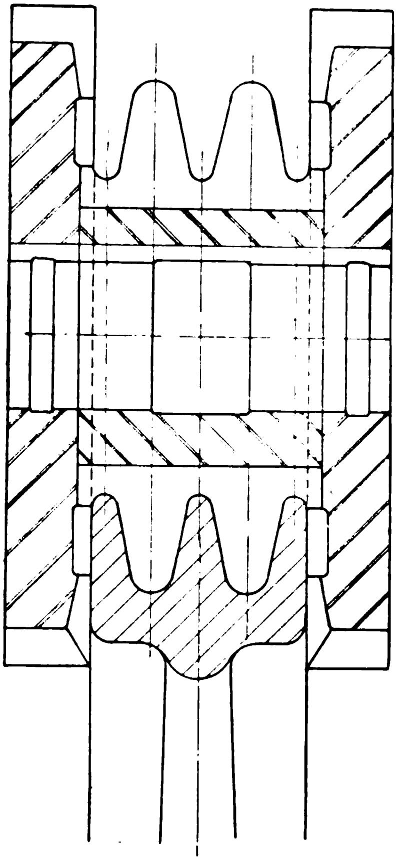


Fig. 11. Gang of Cutters for Circular Milling Rope Pulleys.

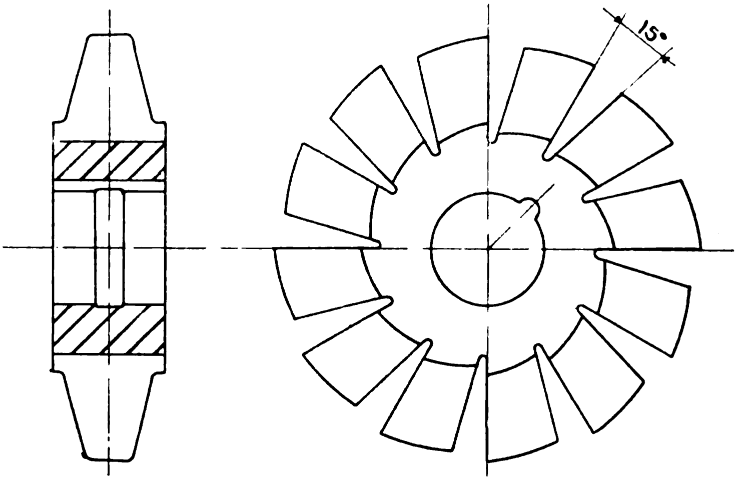


Fig. 10. Formed Milling Cutter.

The transverse slide of the milling machine is first thrown over to set the blank at the required angle with the cutter spindle, and the spiral head is geared to give the required lateral movement of blank in one complete revolution of same, *i.e.*, a distance equal to the lead of the required spiral.

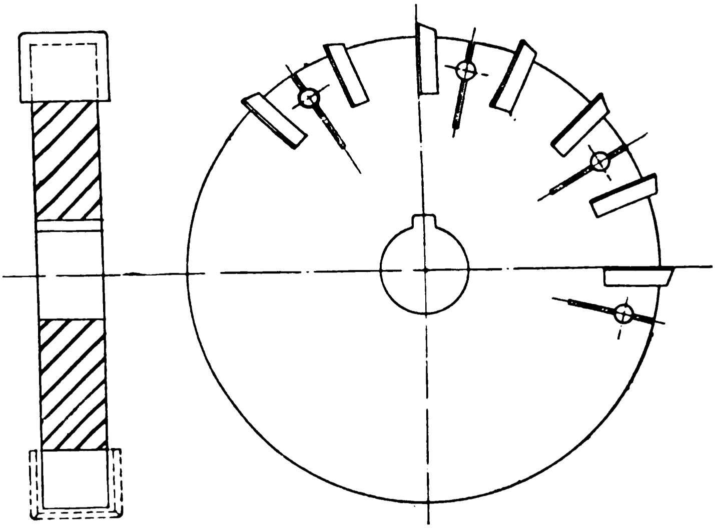


FIG. 12. INSERTED TOOTH MILLING CUTTER.

With an angle of 27½deg. the lead will be in all cases equal to six times the diameter of the cutter.

The lead of spiral may be altered to suit special cases, and should be shorter for roughing cuts than for finishing cuts.

For these special instances the following formula will give the lead required :—

$$\text{Lead} = \frac{\text{Circumference of cutter}}{\text{Tangent of the angle of spiral.}}$$

Angular Cutters. — These cutters are mainly employed for milling the teeth of cutters, reamers, &c. They are made right and left hand, with one side at right angles to the axis of the cutter (see Fig. 7), the most common angles including 45deg., 50deg., 60deg., 70deg., 75deg., and 80deg.

For milling the teeth of spiral cutters special cutters are employed with double angles—a constant angle of 12deg. on one side of the cutter, the other varying from 40deg. to 58deg., the object of this special form being to ensure clearance for the teeth of the angular cutter as the work revolves.

Fig. 6 shows clearly the method of setting this cutter relatively to the work when cutting spiral teeth. These cutters may be made either with ground relief or with machine-relieved teeth.

Formed Cutters.—The machine-relieved or formed cutter is principally employed for profiles of irregular and complicated shapes, and although the formed cutter can be made in any of the more common shapes, *i.e.*, spiral, angular, or side-and-face, where the size permits of the coarser style of formed tooth, the same cannot be said of cutters with ground relief; indeed, there are many forms of work which it would be impossible to reproduce by cutters with ground relief. Figs. 8, 9, and 10 show various types of formed cutters. The method employed in making these cutters is as follows :—

The blank is first turned to almost the

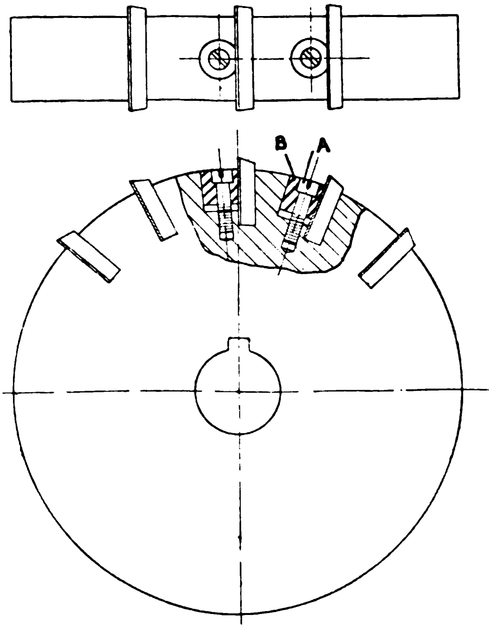


FIG. 13. INSERTED TOOTH MILLING CUTTER.

correct form and dimensions, the spaces separating the teeth being next formed. The teeth are then relieved on a special lathe by a tool having the correct contour, which advances toward the centre as the blank is slowly rotated, each tooth being dealt with in turn. This process is technically known as "backing off."

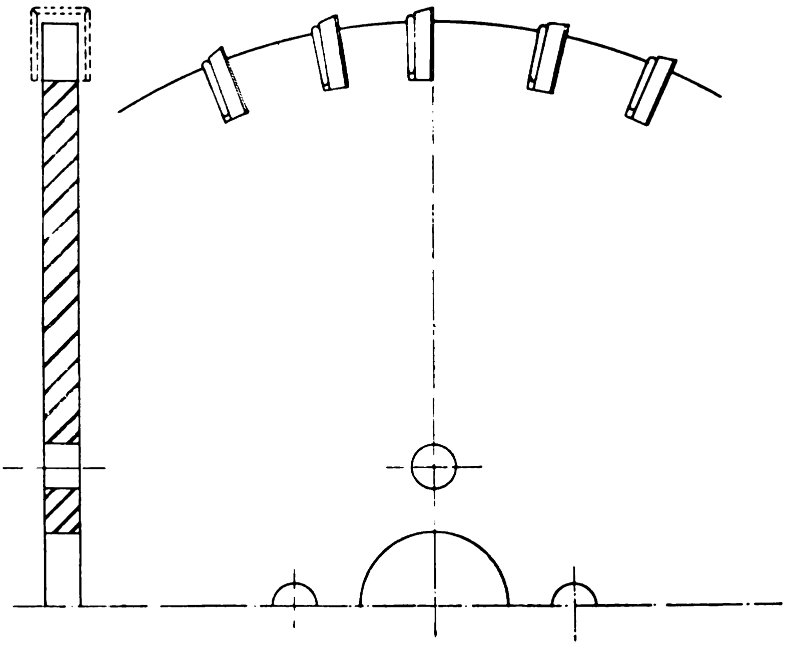


FIG. 14. INSERTED TOOTH MILLING CUTTER.

Sharpening the cutter is effected by grinding the cutting faces of the teeth in the groove by means of a bevelled emery wheel. Extreme caution has to be observed to keep the cutting face constantly radial in grinding in order that the correct profile may be always reproduced. These cutters are ground and used until very little but a thin strip of the original tooth remains. Formed cutters may be used in gangs or in conjunction with cutters with ground relief to suit varying conditions. An example of this is illustrated by Fig. 11, where the required cutters are shown for the circular milling of the periphery of a double-grooved rope pulley.

Inserted Tooth Cutters.—For large cutters, say all over 8in. diameter, the inserted tooth type is for several reasons to be preferred. The chief advantages of this style of cutter are as follows:—

1. The greater portion of the cutter, *i.e.*, the body, is made of cast iron or mild steel. This results in a much lower initial cost of material as compared with a solid cutter of the same dimensions.

2. The steel blades may be made of the very best material, and may be replaced at a very small expense.

3. No danger of the loss of a costly tool in hardening by cracking or breaking.

4. Each blade can be thoroughly hardened, thus reducing to a minimum the difficulties due to local defects in hardening, which are so common with solid cutters.

5. The blades may be adjusted in a direction lengthwise with the axis in order to maintain a standard width, the blades being set alternately to the left and right.

Figs. 12, 13, and 14 show three different methods of fixing the blades.

In Fig. 12 the body is drilled and reamed for a taper pin between every other pair of blades. A saw cut is next made through each taper pin hole, and the pins are driven in to wedge out the metal and tighten on the blades.

Another popular method of holding the blades is illustrated by Fig. 13. The body is drilled with parallel holes in front of the cutter blades. This hole breaks slightly into the slot which receives the blade; the tightening bush B is turned parallel to fit the hole, but has a flat fitting on the radial face of the blade. This flat is cut at an angle with the axis of the bush, which is also drilled radially; the bush thus forms a sort of wedge which is driven in to tighten the blade, and is locked in place by the screw A.

Fig. 14 shows a convenient method of fixing the blades for very narrow inserted tooth cutters, the blades being fixed in position by thin flat wedges.

The tooth angle for inserted blades may be taken at 60deg., with the usual relief angle of 5deg.

The bodies of all inserted tooth cutters should be made of cast iron where the dimensions are sufficient to ensure stiffness and strength. With very small or exceptionally thin cutters of this type the body may be made of mild steel, as per example shown in Fig. 14.

Grinding.—In sharpening cutters of all types, a freely cutting emery wheel of soft grade should be employed, or otherwise the temper of the teeth may be drawn.

Cutters should be frequently sharpened, a good rule being that of sharpening cutters after being used and previous to putting them away. Adherence to this practice will reduce length of time spent on grinding to a minimum, since the grinding of very dull cutters is a laborious and costly operation.

W. Allan Field.

THE WORKS OF ORR, WATT, & CO., LTD., MOTHERWELL.

Among the group of engineering firms in the Glasgow district devoting themselves to the production of constructional work in steel, the firm of Messrs. Orr, Watt, & Co., Ltd., although young, may be reckoned as one of the most promising. The firm has been in existence since April, 1907, and work was commenced at the shops in October of the same year. About nine acres of ground were obtained close to the Edinburgh and Glasgow line of the Caledonian Railway, about four acres of which are now covered with buildings. It was possible by means of the examination of previously existing works of the same nature to commence from the first on thoroughly up-to-date and high-class lines, and one of the features of the works is that the whole of the lighting and power is obtained electrically from the mains of the Clyde Valley Electric Power Co., Ltd., the only heat generated on the works being used for furnaces and blacksmiths' hearths. The illustrations Figs. 1 and 3 show the general appearance of the works, and their equipment may be gauged from the following description.

The template loft is a building of about 50ft. square, which is capable of future extension to a length of 170ft. It is furnished with a wood floor upon which all dimensions of structural steel work undertaken by the firm can be laid out to scale, and accurate templates made, this being one of the features of up-to-date workmanship adopted by the firm. The main shop, which is shown in Figs. 2 and 4, is 70ft. wide and 300ft. long, provision being made for extension both at the ends and sides. An interesting feature of this building is a very light and efficient form of all wood roof for the main span, the only exception to this form of construction being the lean-to for the smith's fires where a corrugated sheet roof is used. Another feature in it is the plant for producing hydraulic pressed trough

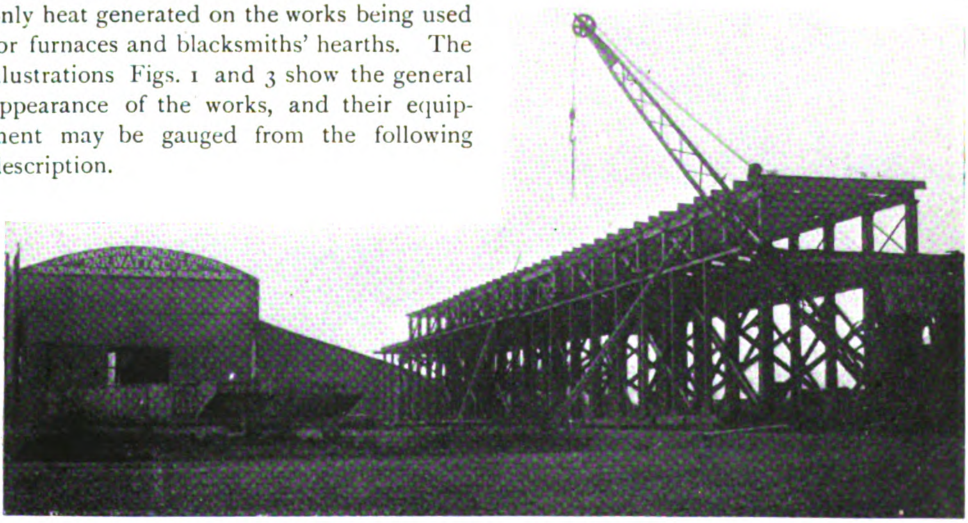


Fig. 1. General View of the Works.

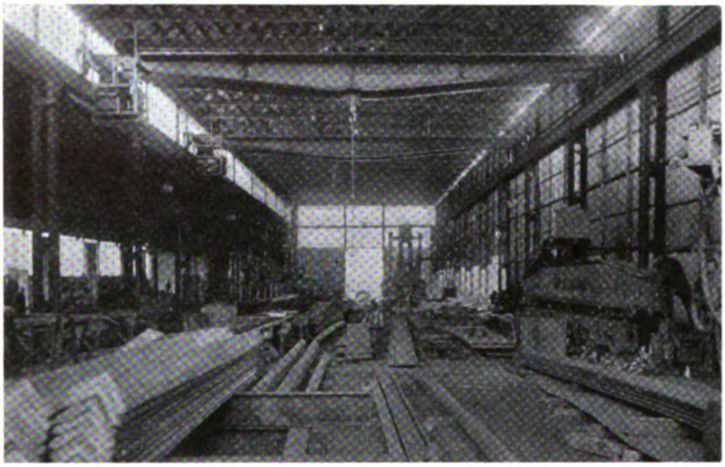


FIG. 2. THE MAIN SHOP.

sections for the floors of bridges, and similar purposes, which are a special manufacture of this firm. The plates for this purpose are first heated in furnaces of the firm's own design, having hearths 13ft. long by 15ft. wide, and are then carried forward on rails to a four-cylinder vertical direct-acting hydraulic press, constructed by Messrs. A. and P. W. McOnie, of Glasgow, and shown in Fig. 5, where they are subjected to a hydraulic pressure of 1500lb. per square inch. This press contains four rams each of 16in. diameter, and capable of a vertical movement of 3ft. The upward pressure exerted by each ram is 130 tons. The cylinders are of a special mixture of cast iron of high tensile strength, and are bored to suit the rams, which carry four massive tables to which the working dies are attached. Below each cylinder and directly over each table are massive mild steel girders which are connected together by means of mild steel columns of large diameter securely fixed thereto. The press is operated by means of a single handling valve which is connected to all four cylinders by a pipe which carries four subsidiary valves. These valves enable any one or more cylinders to be isolated so that the pressure exerted may

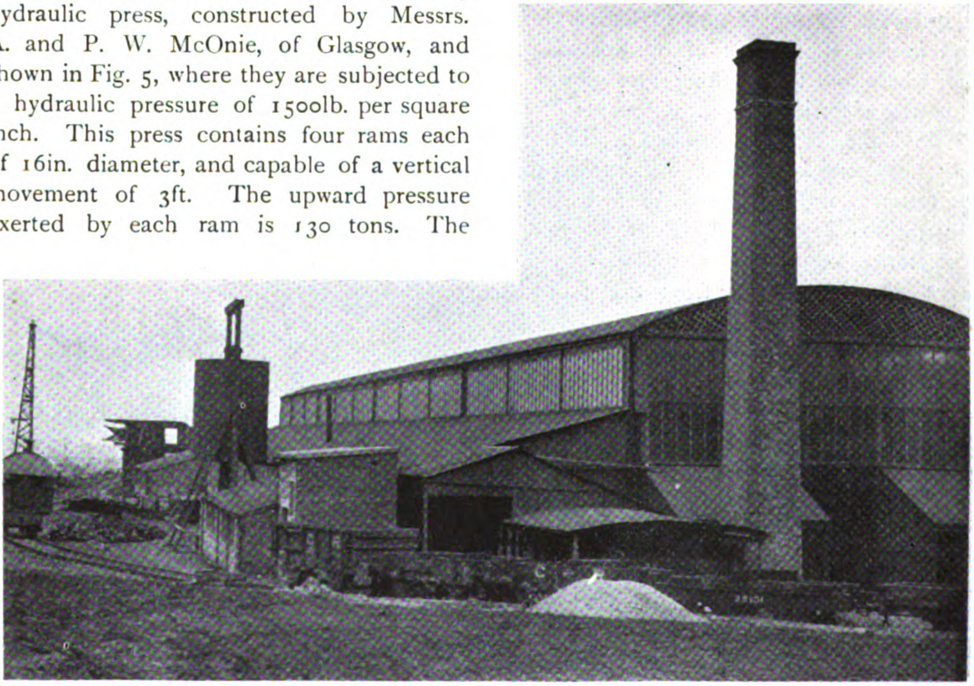


FIG. 3. GENERAL VIEW OF THE WORKS.

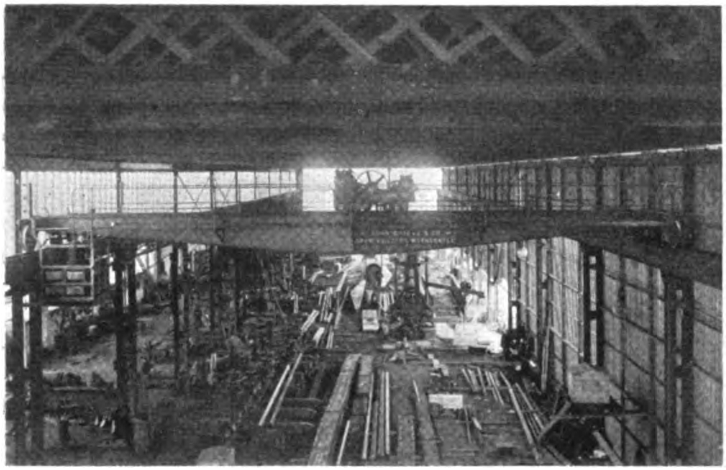


Fig. 4. The Main Shop.

press is altogether of strong and massive design, and has given entire satisfaction for the work for which it was intended.

be increased or diminished according to the requirements of the work in hand. The

In connection with this plant is a straightening machine built by Messrs. Chambers, Scott & Co., driven by a 7½ b.h.p. motor, while the plates are lifted by means of two self-contained hand and hydraulic jib cranes built by Messrs. Rice & Co., Ltd., each capable of dealing with 40cwt., up to 25ft. radius. For the purpose

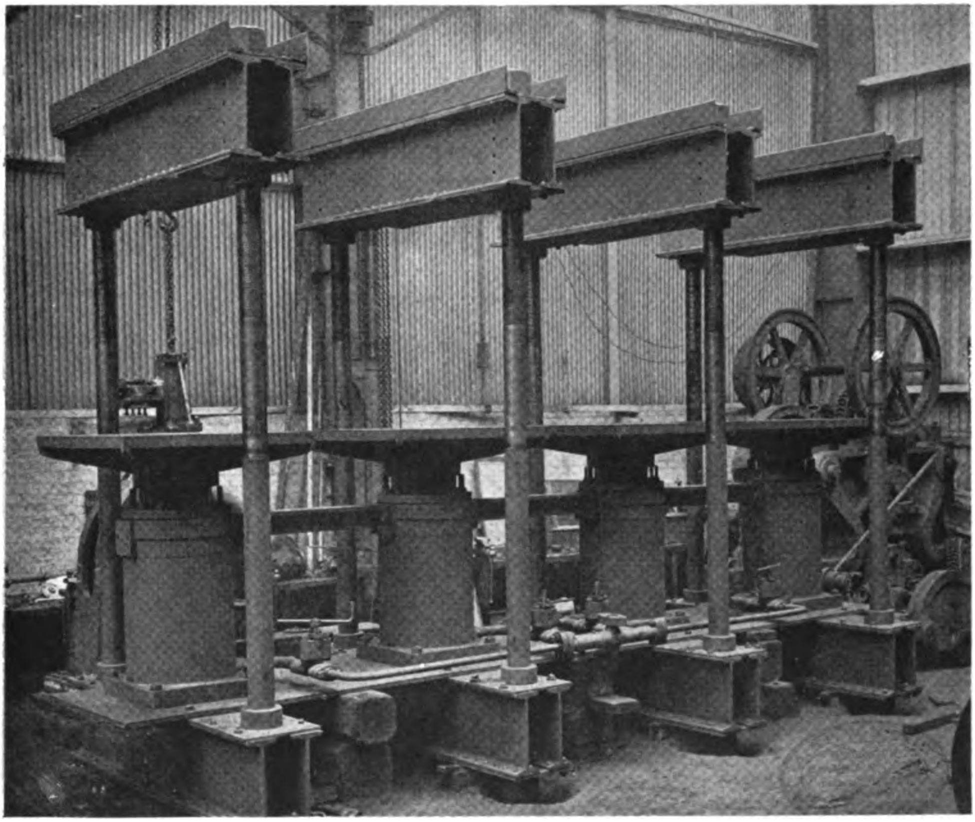


Fig. 5. Vertical Direct-acting Hydraulic Press.

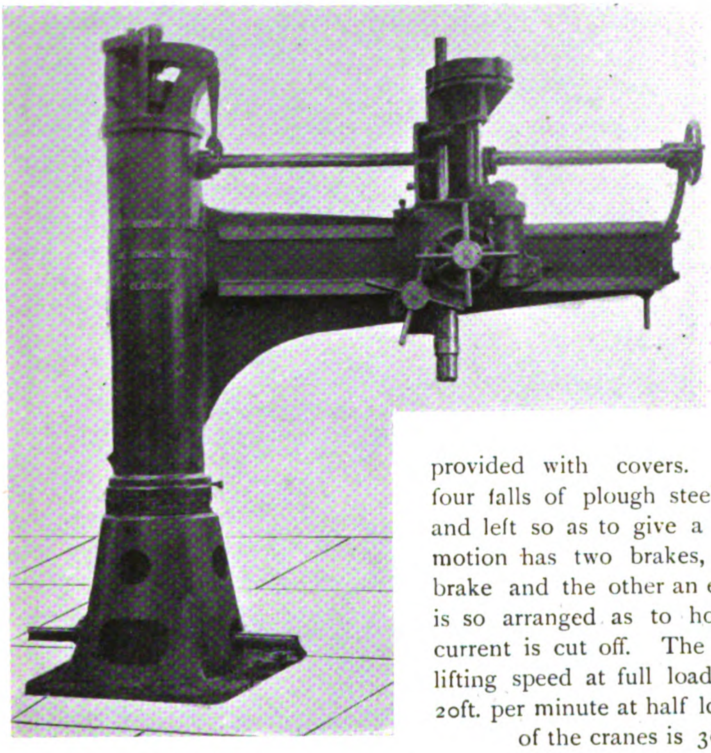


Fig. 6. Radial Drill.

of bending plates, a set of flat rolls, constructed by Messrs. Chambers, Scott, are driven by a 15b.h.p. motor. The shop is commanded by two 10-ton overhead travelling cranes, built by Messrs. John Grieve & Co. Both cranes are similar in construction, and have a span of 48ft. They are of steel construction, the main girders being of double web section, the end carriages being of box section, and the trolleys being of steel beams. The gearing wheels are all steel, and have machine-cut teeth. The bearings are all bushed with bronze, and are provided with covers. Hoisting is effected by four falls of plough steel wire rope, coiling right and left so as to give a vertical lift, and the hoist motion has two brakes, one being a mechanical brake and the other an electro-magnetic one which is so arranged as to hold the load whenever the current is cut off. The three-phase motors give a lifting speed at full load of 10ft. per minute, and 20ft. per minute at half load. The travelling speed of the cranes is 300ft. per minute, while the traverse is 80ft. per minute. Fig. 4 gives an

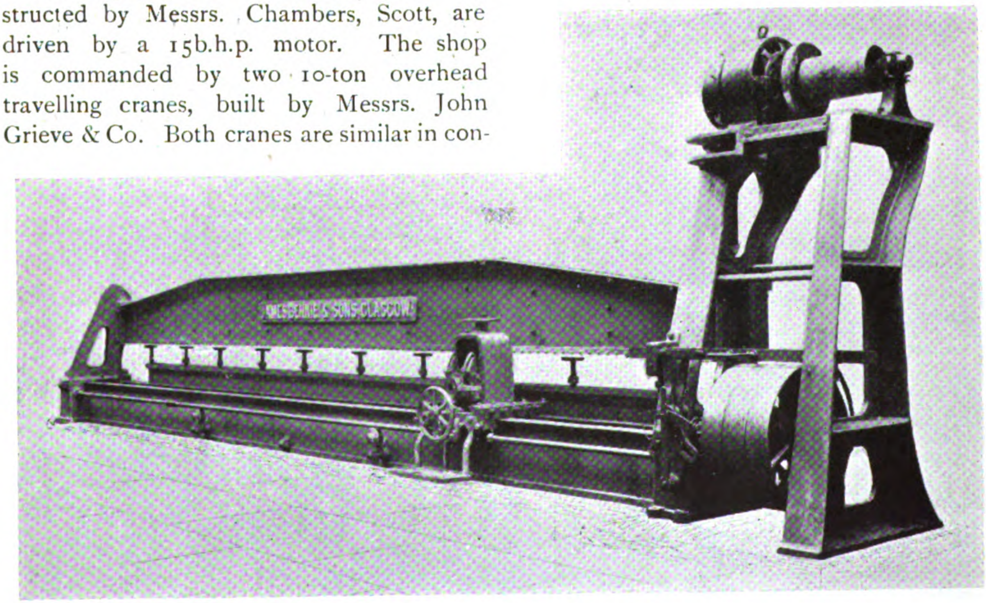


Fig. 7. Plate-edge Planing Machine.

excellent view of one of these cranes, while Fig. 2 shows the two cranes at work in the shop.

Group driving is adopted in the case of a set of six high-speed radial drills by Messrs. James Bennie & Co., operated by a 25b.h.p. motor. These drills, shown in Fig. 6, are arranged to swing complete circles, and are driven from shafting underneath. The maximum radius of the spindles is 5ft. 6in., their diameter is 2in., and speed 350r.p.m. The rate of feed given is 3½in. per minute, and the spindles are provided with a quick lifting arrangement, are balanced, and have ball thrust bearings. A line shaft driven by a 25b.h.p. motor operates two cold saws, a surface planing radial drill, Pilkington power hammer, horizontal drilling machines, lathe, and small pump. One of the interesting machines in this shop is an edge planing machine by Messrs. Bennie, capable of taking plates up to 30ft. long, and operated by a 40b.h.p. motor. This machine has a main driving screw 6in. in diameter, is arranged to cut at a speed of 40ft. per minute, and will work on plates up to 3½in. thick. Fig. 7 illustrates this machine and its motor equipment.

The same firm have also supplied a 1¼in. by 1¼in. lever punching and shearing machine operated by a 15b.h.p. motor, shown in Fig. 8, the punch gap of which is 30in. deep and the shear gap 27in. deep; and an angle cutter to cut 6in. by 6in. angles. Among other applications of electric drive may be mentioned a 15h.p. motor driving bending rolls, bevel cropper, buff and screwing machines, while Keith-Blackman electric blowers are used for the purpose of giving blast to the smiths' fires.

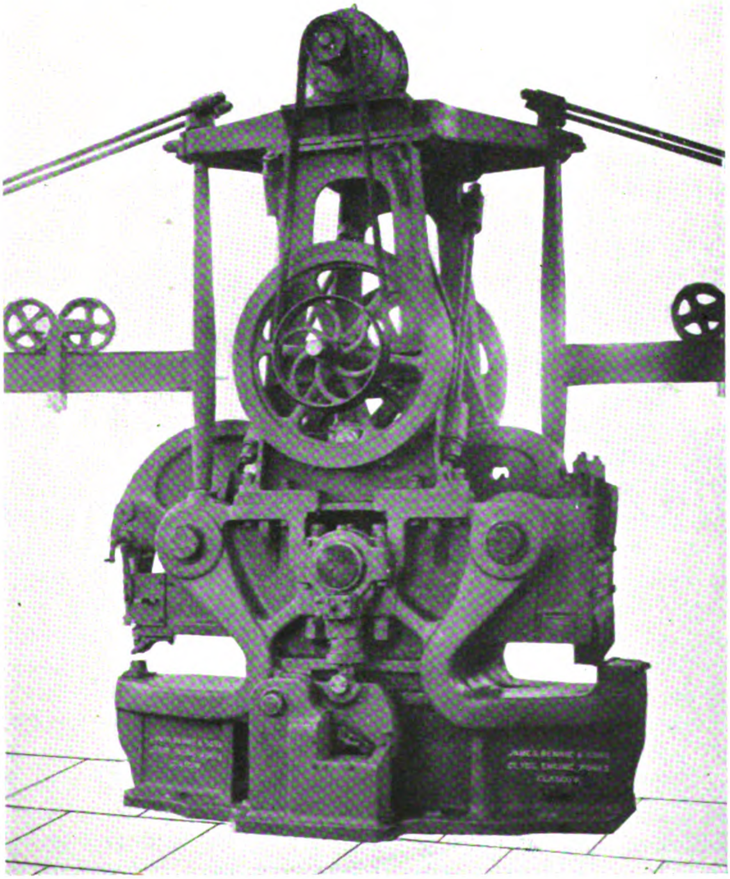


Fig. 8. Punching and Shearing Machine.

The electric supply is brought from the Clyde Valley system at a pressure of 400 volts between phases on the three-phase system, a main switchboard being erected on the works capable of dealing with 200 amperes per phase. The main switchboard has three panels, and the whole supply is controlled by a three-pole switch with fuses in series on each phase. The supply then passes to the firm's own main switch and fuse circuits, passing respectively to the shops, pumps, compressor, and a motor generator for the purpose of supply to the drawing offices, where a photographic machine is operated up to 110 volts. The lighting in the offices is on the alternating-current system, brought down to 230 volts for the purpose of incandescent glow lamps. All the arc lamps in the shop are supplied by means of direct current, two lamps being placed in series. The distribution is carried throughout the works by means of insulated conductors on porcelain insulators except in the case of overhead pole wires, where bare wire is used. The circuits pass from the central switchboard to a starter for each motor at a pressure of 400 volts and 25 cycles per second. With the exception of slip-ring motors on the cranes, and the motor driving the hydraulic pumps, all motors are of the squirrel-cage type, started by means of auto-starters. The central switchboard is located in the main motor room, where a 55b.h.p. slip-ring motor drives a set of hydraulic pumps constructed by Messrs. A. & P. W. McOnie. These pumps are of the horizontal belt-driven type, suitable for a working pressure of 1500lb. per square inch. The pumps (four in number) are in pairs cast together with the valves neatly arranged on top. This permits of easy access for examination and repairs. The rams are securely fixed to crossheads and are connected together by means of mild steel rods, which are clearly shown in the accompanying illustration, Fig. 9. The drive is effected by means of a spur pinion gearing into a large spur wheel keyed to the crank shaft. To each end of this shaft is fixed a crank disc carrying a connecting rod the tail end of which connects to one of the crossheads on the end of the ram. These pumps work in conjunction with a hydraulic accumulator of large capacity, capable of supplying the whole of the hydraulic machines in the works with water at 1500lb. per square inch. The motor runs at 480r.p.m. and takes 80amp. per phase, the brushes being continuously kept on the slip-rings. The auto-switch, which is of a novel type, is controlled from the hydraulic accumulators.

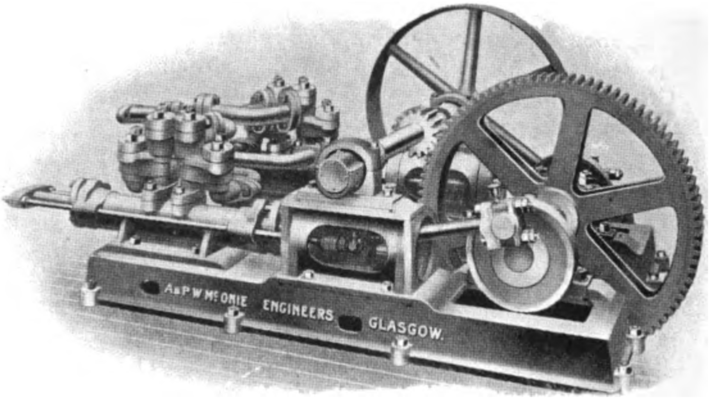


FIG. 9. HYDRAULIC PUMP.

In the same room is an Alley & MacLellan air compressor, driven by means of a 55b.h.p. motor running at 710r.p.m., and driving the compressor by means of internal spur gear. The motor has a raw-hide pinion which works inside the rack of the flywheel on the compressor. The set is capable of delivering 200 cubic feet of free air per minute at 100lb. pressure, running at 225r.p.m. The compressor embodies Messrs. Alley & MacLellan's patent air valves, consisting of one piston valve with three concentric pistons and two sets of discharge check valves, and intercooler through which all air passes on its way to

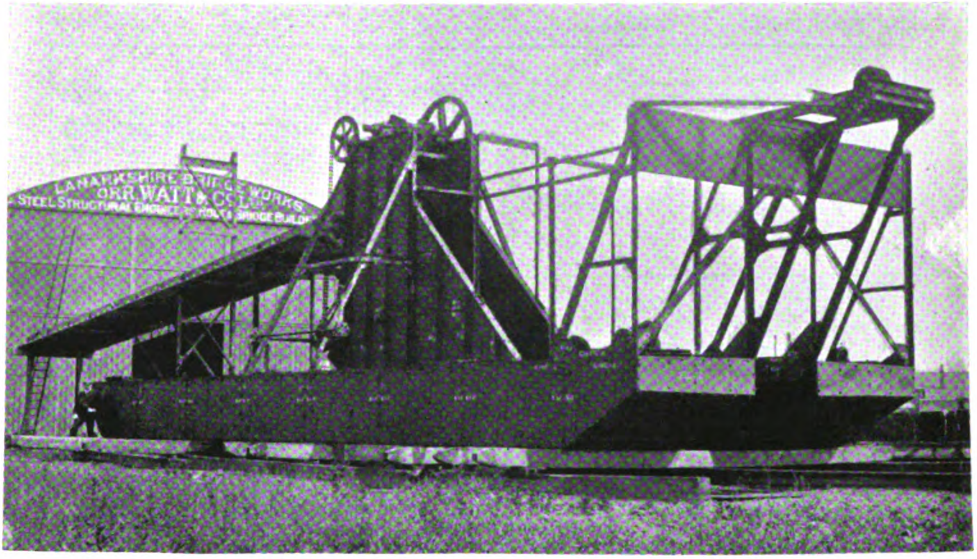


FIG. 10. A GOLD-PROSPECTING DREDGE FOR SIBERIA.

the discharging cylinders. The motor generator for the photographic printing machine in the offices and for the arc lighting has a motor of 15b.h.p., running at 710r.p.m., the generator giving 100amp. direct current at 105 volts. In the yard is a seven-ton derrick crane constructed by Messrs. D. Watson & Co., and driven by a 15b.h.p. slip-ring motor.

Although the works have only been in operation for a comparatively short time, the firm has been very successful in developing its trade. At the present time it is engaged in interesting structural work for the Great Northern Railway of Ireland, substituting a steel bridge for an existing wooden erection without disturbing traffic. For this purpose steel cylinders 6ft. in diameter, filled with concrete, have had to be sunk, some as far as 52ft., by means of compressed air, in order to reach firm ground. Four other bridges for the same company are also under course of construction, while previous contracts have included large orders for the Cape Government Railway, Indian State Railways, the furnishing of material for a steel piled wharf at Canton, a jetty and wharf in India, &c. Besides this class of work they have constructed a gold prospecting dredge for Siberia (illustrated in Fig. 10), steel work for three large theatres in England, and general steel work, such as tanks, chimneys, barges, pontoons, and caissons. It will therefore be seen that a forward policy has been pursued by the firm, in which it is greatly assisted by the up-to-date nature of the works equipment.

	Passes	Stand No.						
		1	2	3	4	5	6	7
Test No. 1. Size of Billet .. 1¼"×1¼"×25' 0¼" Wt " " ... 11 Lb. Carbon .. ·80 Size of Fin. Stock 1⅛"×16 S.W.G.×45'0"	1	·155 —	·207 —	·025 │	·033 —	·038 —	·034 —	·021 —
	2	·078 —	·138 —	·035 —				
	3	·053 ◇		·025 │				
	4	·027 ◇						
Test No. 2. Size of Billet .. 1¼"×1¼"×76" Wt. " " ... 32 Lb. Carbon .. 1·20 Size of Fin. Stock .. 1"×3/16"×47'0"	1	·1116 ◇	·425 —	·104 │	·0491 │	·051 │	·0492 │	·0416 —
	2	·102 ◇	·283 —	·034 —	·034 —	·0416 —		
	3	·0492 ◇						
	4							
Test No. 3. Size of Billet .. 1¼"×1¼"×76" Wt. " " . 32 Lb. Carbon · 1·20 Size of Fin. Stock .. 1 3/16"×3/32"×34'6"	1	·335 —	·228 —	·147 │	·0716 │	·1018 │	·0329 │	·0218 —
	2	·168	·1002	·0473	·045			
	3							
Test No. 4. Size of Billet .. 1¼"×1¼"×36" Wt " " .. 16 Lb. Carbon .. ·90 Size of Fin Stock .. 3/8" Round.	1	—	⬭	◇	—	—	⬭	○
	2	⬭	◇	◇				
	3	◇						
	4							
Test No 5. Size of Billet · 2 3/16"×3/16"×47" Wt " " · 10¾ Lb. Carbon .. ·80 Fin. Stock .. 2"×·041"×35'0" * Load Very Light. ϕ Stock at Black Heat Leaving Pass.	1			·073 │	·098 —	·098 —	·0375 —	·0219 — ϕ
	2			·305 —			·0312 —	
	3			·0278 │ *				
	4			·0491 —				
Test No. 6. Size of Billet · 1¼"×1¼"×9'8" Wt. " " .. 50 Lb. Carbon .. ·90 Fin. Stock : 5/16" Round × 196'0" Note · Started to Thread when leaving Third Pass	1	·529	·3315 ⬭	3/8" ◇	·043 ⬭	5/16" ◇	5/16" ⬭	·0206 ○
	2	·473 ⬭						
	3	◇						
	4	·099 ◇						
	5	◇						
Test No 7. Size of Billet · 1¼"×1¼"×5'6" Wt " " 26·6 Lb. Carbon · 1·29 Fin Stock · 1"×·193"×36'0" * These Two Passes in Same Groove ϕ These Stands were Uncoupled	1	·1087 ◇	·3480 —	·0517 │	·0517 │	·0645 —	ϕ	ϕ
	2	·0995 ◇	·3130 —	·0295 —	·0498 │			
	3	·0203 ◇	·0645 — *					
	4		·1380 │					
	5		·0295 — *					
Test No. 8. Size of Billet 1¼"×1¼"×61" Wt " " 24·5 Lb Carbon · ·85 Fin Stock : 13/32" Round × 51'6" Note · Was Threaded from 3rd. to 4th Stand	1	—	⬭	◇	—	—	⬭	○
	2	⬭	◇	◇				
	3	◇						
	4							

Table of Data of Eight Tests.

POWER REQUIREMENTS FOR ROLLING HIGH-CARBON STEEL

In a paper recently read by Mr. B. Wiley before the American Institute of Electrical Engineers, valuable results of electric rolling-mill practice were set forth.

The figures of tests given in the paper were taken from a 9in. merchant mill, a plan of which is shown in Fig. 1. The mill consists of seven stands of three-high rolls and one finishing stand of two-high rolls driven by a two-speed, two-phase, 60-period, 2200-volt induction motor of squirrel-cage rotor construction, connected to the mill by means of a 42in. three-ply belt. The ratings of the motor are 600h.p. at 600r.p.m. (synchronous speed) and 450h.p. at 450r.p.m. The pulley reduction gives a mill speed of one-half these values.

The product of the mill is high-carbon steel of comparatively small sections, test data (see page 90) being given for steel ranging from 0.80 to 1.29 carbon, and of sections ranging from $\frac{3}{16}$in. by $\frac{1}{32}$in. to $\frac{5}{16}$in. round. Originally the intention was to run the mill on the slow speed for the larger sections and on the high speed for the small rounds and very thin flats, but on testing the high-speed operation it was found that special provision would have to be made for handling the stock as it was being rolled, including the use of repeaters for the finishing stands. These plans have not been fully developed, and all material is being rolled on the slow speed. The results obtained under these conditions are most gratifying, as a comparison with a steam-engine driven mill of the same general design but of five stands of rolls shows that the capacity of the latter mill is exceeded by that of the motor-driven mill by 35 per cent. This difference is partly due to the two additional stands of rolls, but

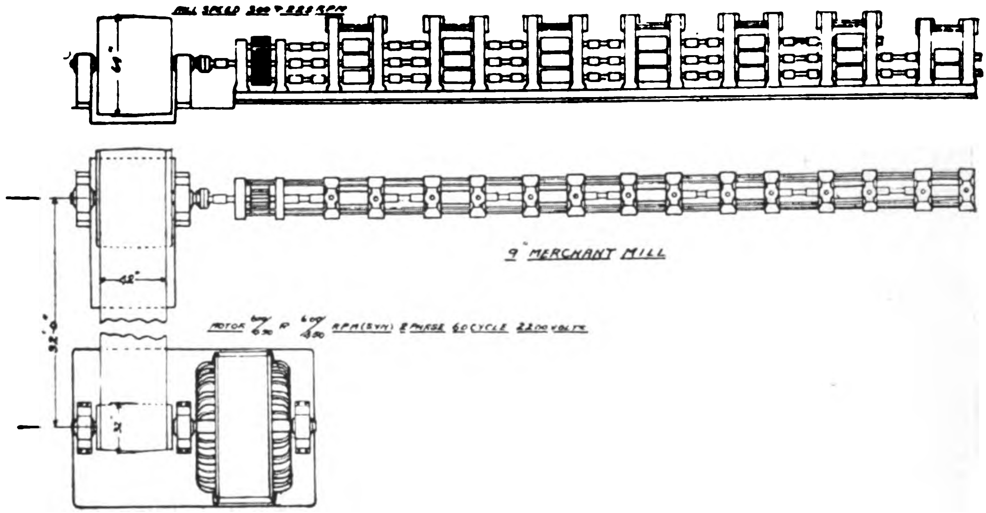

MILL SPEED 300 ÷ 225 RPM
9" MERCHANT MILL
42"
32'0"
MOTOR 600/450 HP 600/450 RPM (SYN) 2 PHASE 60 CYCLE 2200 VOLTS

FIG. 1. GENERAL ARRANGEMENT OF ELECTRIC ROLLING MILL.

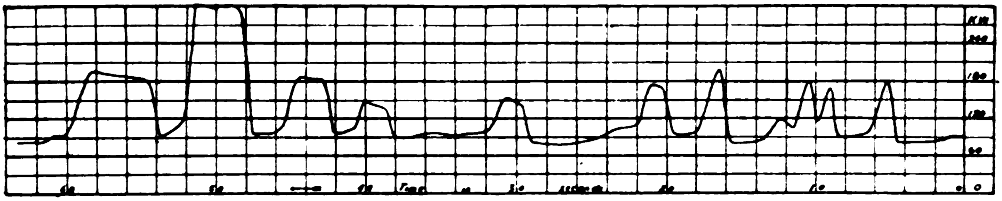


FIG. 2. ONE PIECE IN ROLLS. TEST NO. 1.

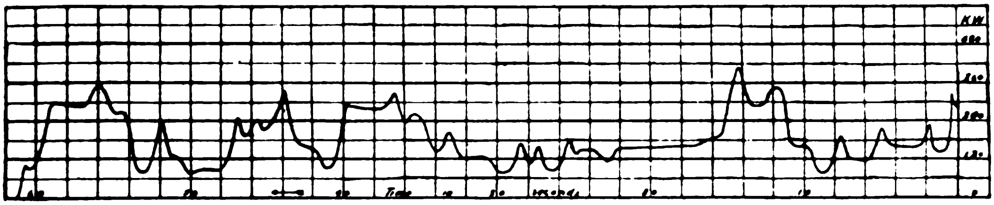


FIG. 3. ROLLING CONDITIONS. TEST NO. 1.

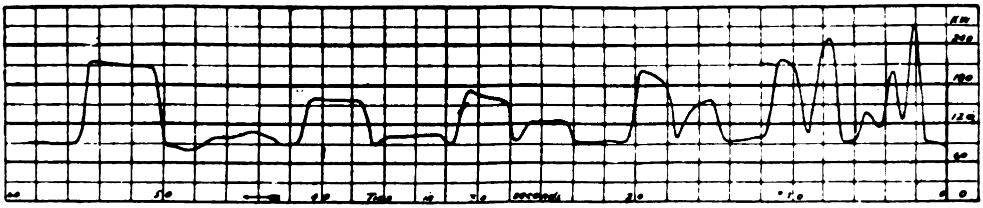


FIG. 4. ONE PIECE IN ROLLS. TEST NO. 2.

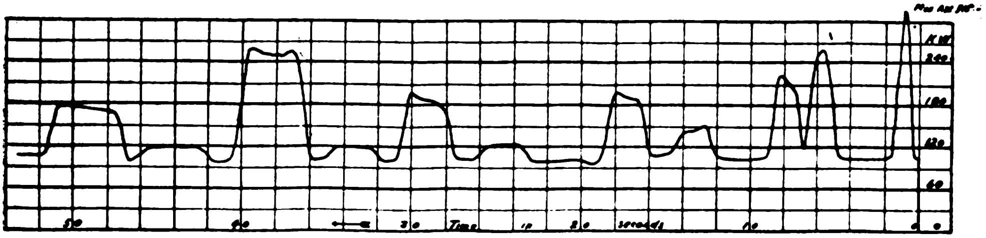


FIG. 5. ONE PIECE IN ROLLS. TEST NO. 3.

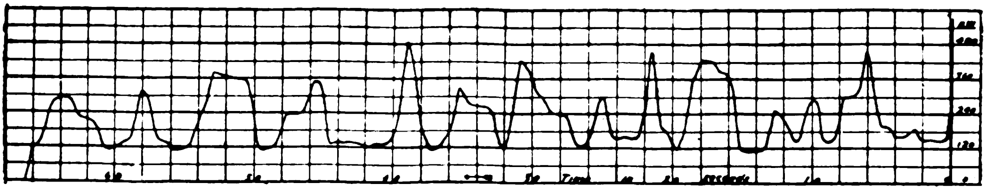


FIG. 6. ROLLING CONDITIONS. TEST NO. 3.

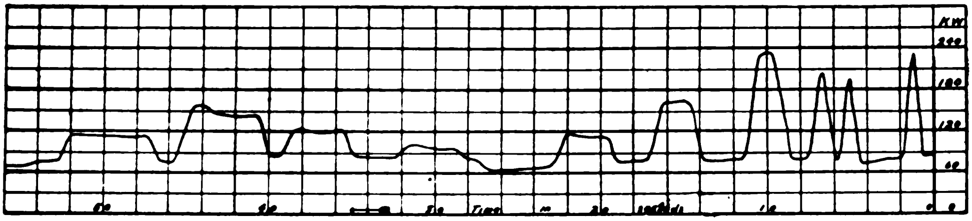


FIG. 7. ONE PIECE IN ROLLS. TEST NO. 4.

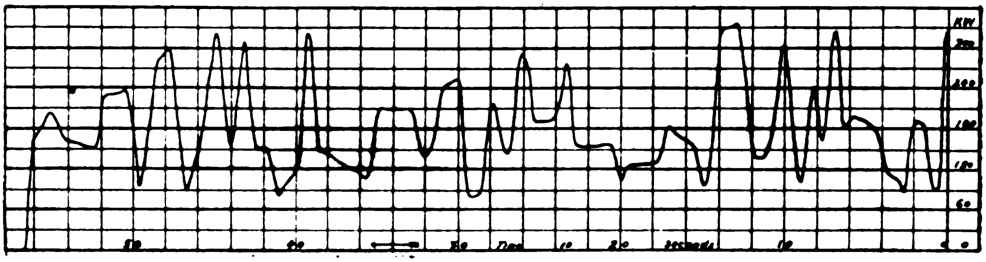


FIG. 8. ROLLING CONDITIONS. TEST NO. 4.

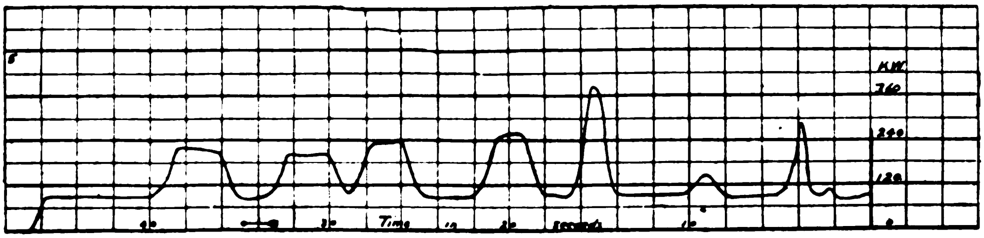


FIG. 9. ONE PIECE IN ROLLS. TEST NO. 5.

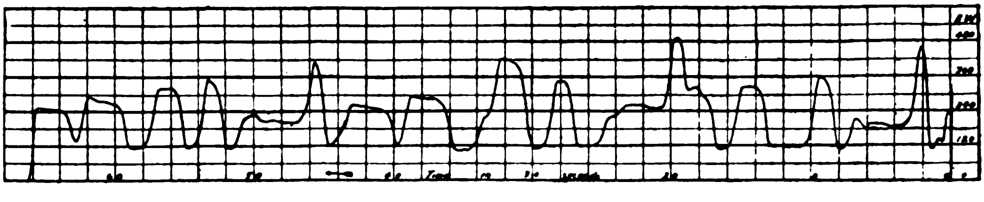


FIG. 10. ROLLING CONDITIONS. TEST NO. 5.

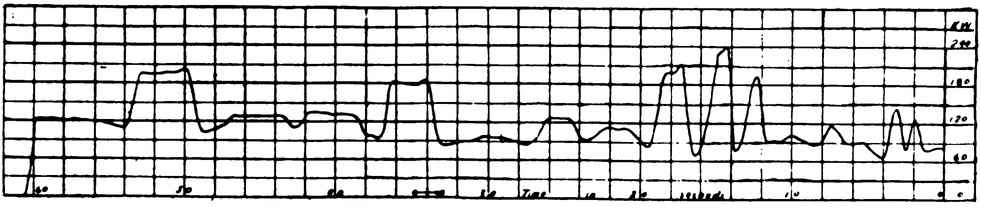


FIG. 11. ONE PIECE IN ROLLS. TEST NO. 6.

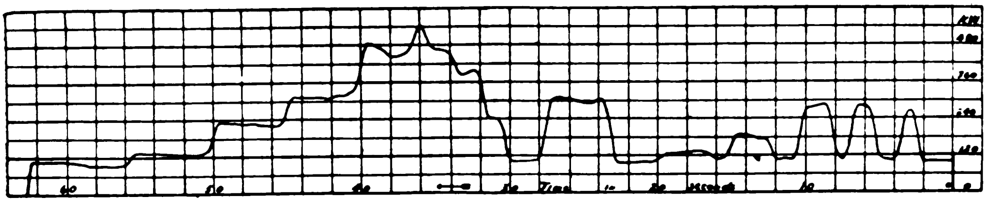


FIG. 12. ONE PIECE IN ROLLS. TEST NO. 7.

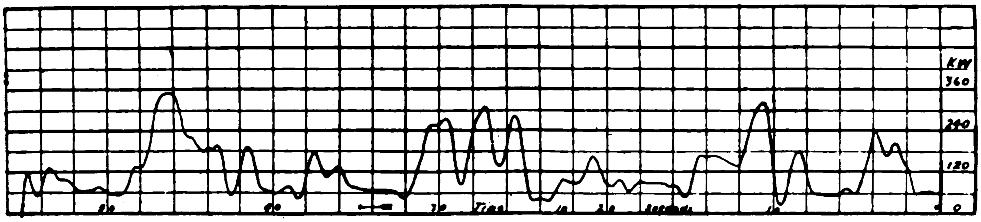


FIG. 13. ROLLING CONDITIONS. TEST NO. 7.

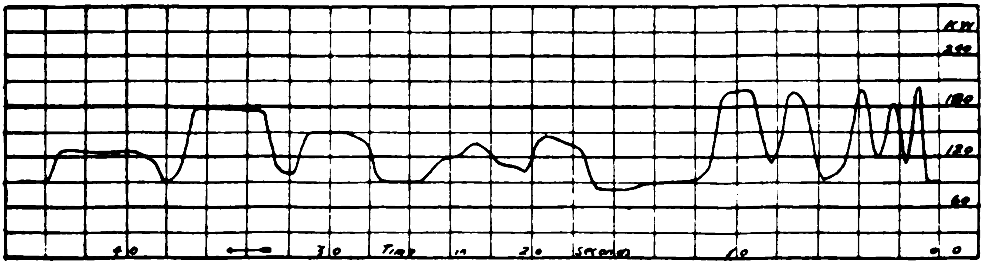


FIG. 14 ONE PIECE IN ROLLS. TEST NO. 8.

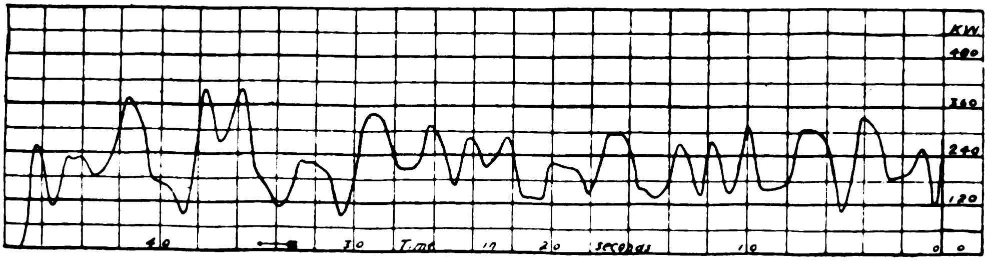


FIG 15. ROLLING CONDITIONS. TEST NO. 8.

chiefly to the practically constant speed of the motor, as the average speed of the engine is appreciably reduced by the heavy load conditions.

It will be seen that the areas of the sections at each pass are only approximate, but the relative values, which are of more importance, give a good idea of the operating conditions and work done.

The recorded readings as shown by the series of curves were taken to obtain the power required per pass, the total power for one piece of stock, and the power requirements when the mill was in regular operation with several pieces of stock in the rolls at one time. These latter data were, however, not obtained for tests Nos. 2 and 6.

An all-day record as follows was kept during test No. 7. The results give a good idea of the capacity and the average power requirements per ton of product.

Records observed from 6.55 a.m. to 3.49 p.m.

Size of stock rolled, 1in. by 0.193in. by 36ft.
Carbon, 1.29.
Size of billet, 1.25in. by 1.25in. by 5ft. 6in.
Weight of billet, 26.6lb.
Number of billets rolled, 1121.
Total weight of billets, 29,818lb.
Actual operating time, 408min.
Time lost, 126min.
Total kilowatt-hours, 1140.
Kilowatt-hours friction load, 408.
Kilowatt-hours (including friction) per ton of metal rolled, 71.2.

Record readings as shown in Figs. 12 and 13 were taken during the above run.

The fly-wheel effect of the system is practically limited to that of the rotor of the motor: this effect is comparatively small, as the slip of the motor is but three per cent. at full load. The efficiency of the motor is, therefore, kept as high as possible. By referring to Fig. 6 (test No. 3) it will be seen that the peak-load conditions have a duration of approximately six seconds. To equalise this load to the average power would require an excessively large fly-wheel on the mill-shaft, and the slip of the motor would have to be increased to approximately three times the present value, thereby lowering the efficiency of the motor.

From the average working conditions as estimated from the various power curves for usual mill operation, it would require approximately a 15-ton fly-wheel, 8ft. in diameter, with a 10 per cent. drop in speed for 250h.p. increase of load in order to lower appreciably the peak values of the load. The time and efficiency costs of this equalisation do not warrant the use of a fly-wheel in the system.

The friction load of the mill is somewhat high, this being due principally to the fact that it is necessary to keep the mill adjusted very closely. Every precaution is taken to keep the mill tight, which results in heavy pressures in the bearings.

It is generally supposed that, due to its hardness, more power is required to roll the high-carbon steel than the ordinary mild steel, but at the same temperatures the energy required is practically the same. Owing to the high percentage of carbon the harder steel billet must not be heated as hot as the milder steel, and it is therefore rolled at a lower temperature, the lighter sections being finished at a black heat.

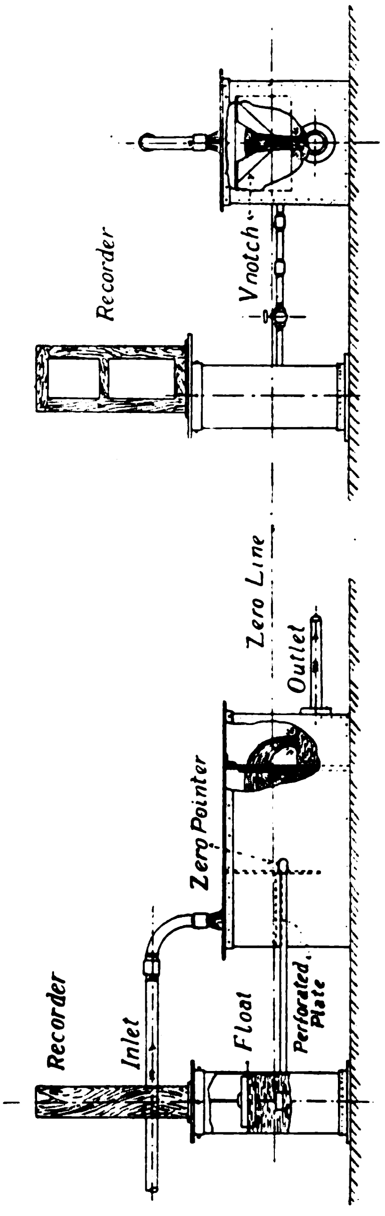
◆

A STEAM ECONOMY RECORDER.

In the course of a recent discussion on power-station economy, it was pointed out that the internal-combustion engine has one special and peculiar merit in which it excels the steam engine. The internal-combustion engine will not work at all unless it is in good and economical working order. On the other hand, it is a well-recognised fact that the steam engine undergoes a steady and continuous diminution of economy unless it is perpetually under observation and maintained up to the mark. The internal-combustion engine may be said to match itself, and though it does not keep itself in order, it does refuse to work when in bad order in respect of piston tightness. A steam engine may be working very wastefully although it may appear to be in excellent order. There is nothing in its running to draw particular and pointed attention to incipient defects, and losses may go on for a long time unobserved or unattended to, which would be promptly rectified were their extent plainly recognisable. Anything, therefore, which helps to point out the presence of wasteful working commends itself for use in the power house. An instrument for this purpose, and one that is coming much into common use, is an automatic recorder of the air-pump discharge water from surface condensers. This device, known as the Lea recorder, is extremely simple in principle. Primarily it may be said to be based on the fact that water flowing over a **V** notch does so at a rate that is represented by a formula with a constant coefficient. This coefficient is 0.305 in the formula $G = 0.305H^2\sqrt{H}$, where G = gallons per minute and H is the height of the water level in the tank, well back from the notch, measured above the point of the **V**. The above formula holds good for a 90deg. notch. For smaller quantities of water the angle of the notch is made less, and the flow per minute is correspondingly reduced. The flow over a notch is proportionate to the area, and the area of a **V** is, of course, proportionate to the square of the vertical height. Similarly the rate of flow is a matter of head, and varies with the square root of the head. Hence the term $\sqrt{H}$ in the formula. If a float with a vertical staff and pointer be immersed in the tank and adjusted so that the pointer stands at zero on the scale when the tank has run away its contents down to the point of the notch, then the water level above the notch will be shown by the height of the pointer above zero. This height is the term H in the formula, and from the reading of the pointer the yield at that moment can at once be calculated. In the instrument itself, however, this calculation is made so that the rate of flow can be read off directly from the position of the pointer on a paper chart rolled round a clock-driven drum.

The calculation is effected as follows:—A rod attached to the float is cut into a toothed rack on its upper end, and this rack engages with a pinion on the spindle of a small cylinder. This cylinder is, therefore, caused to rotate as the float rises and falls. On the cylinder is cut a groove with an increasing spiral. The spiral in fact is cut to suit the formula $0.305\ H^2\sqrt{H}$, and in the groove runs a pointer attached to the slider which carries the recording pen. The movement of the recording pen is thus made to vary as $H^2\sqrt{H}$, and so at any position it shows the rate of flow over the notch. The mean rate of flow during any period of hours can be found by means of a planimeter, the total diagram area above zero being measured to find the total flow, and this, being divided by the time, gives the mean flow. If the flow of water be then compared with the reading of the recording wattmeter, the steam per kw.-hour can be found instantly.

If an engine is known to be under a steady load, and the reading of the recorder changes, this may be taken as requiring explanation. An air leakage may have commenced, spoiling the vacuum; or a hot bearing may have reduced the mechanical efficiency; or, again, something may have gone wrong at a superheater. Something calls for attention. The utility of the instrument may be tested by changing the low-pressure cut-off: as soon as the change takes effect, and more or less water begins to flow, the recording pen will move to its new position. A few seconds of time are required to show this, and it is obvious that not many minutes would be needed to determine almost exactly the best point of cut-off in the second or third cylinder, or the effect of throttle governing wholly or partially in place of expansion governing. Such determinations will in the ordinary way take weeks of time, and the many tests necessary give only approximate results. The recorder reduces their definition to hours and minutes, and the immediate results are free from the disturbing effects of the changes which must take place during long tests—changes which may even nullify the results sought, especially near the points of maximum effect when performance curves are near the horizontal.



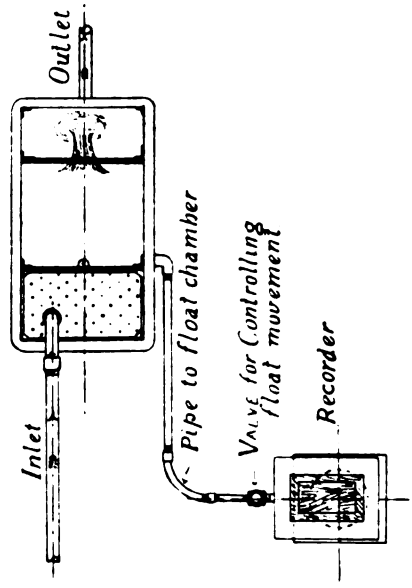


Fig. 1. General Arrangement of the Lea Recorder.

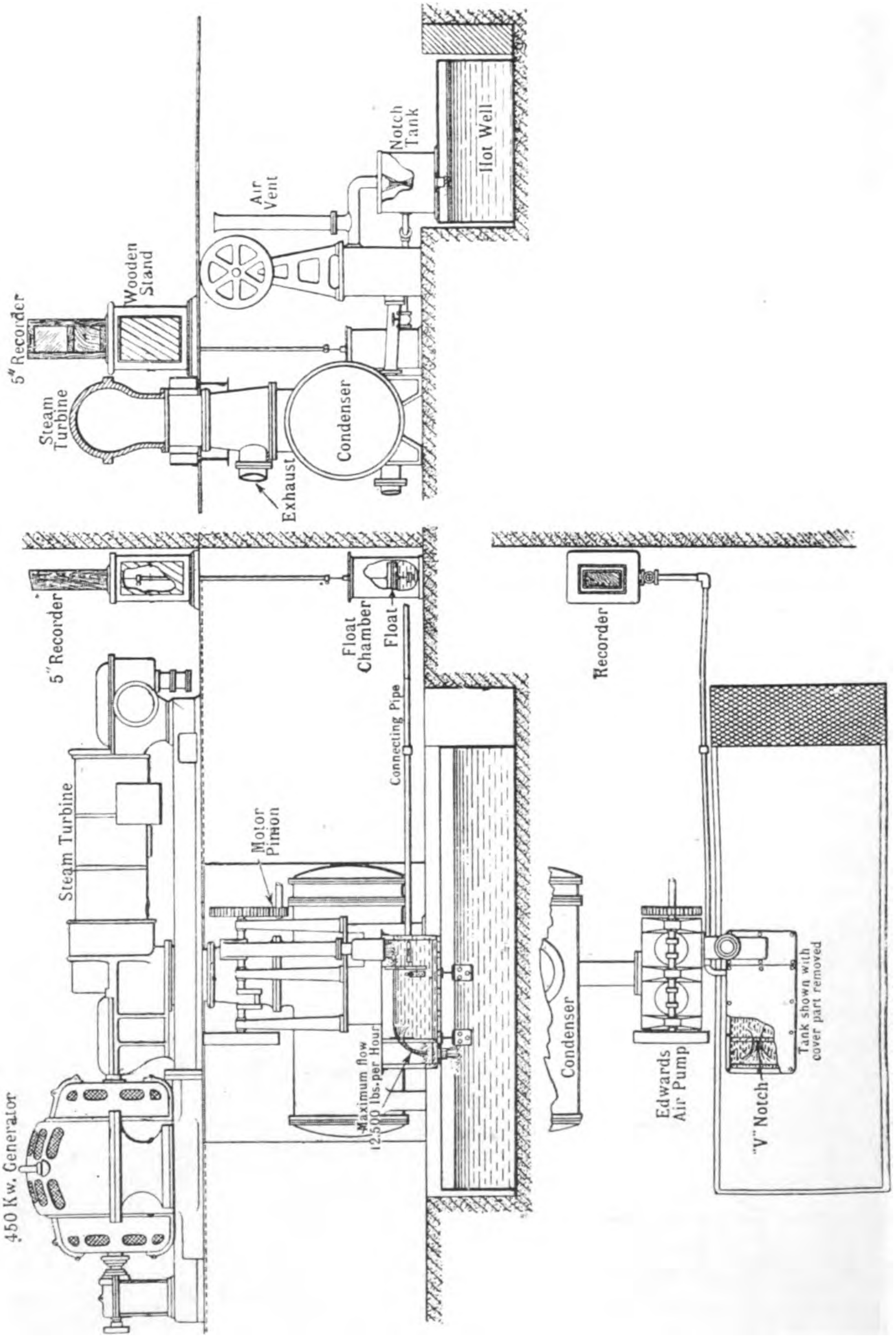


Fig. 2. Plan and Elevation of Application of Lea Recorder to Turbo-generator Unit.

The recorder may be employed to test the value of different degrees of superheat all the way up the scale from ordinary wet steam to steam 1deg. superheated, and therefore dry, and up to steam at 500deg. or 600deg. F. Then, again, the recorder might be used to ascertain the true commercial high-vacuum limit for engines or turbines, and so on; all manner of tests may be made at no cost worth naming, for any costly change would not be allowed to run long.

The best and most immediate results from the use of these recorders are only to be obtained when every engine or turbine has its own condensing plant. Where several engines are connected to one condenser any change in one engine purposely made can be traced on the record, although obviously a change worth 5 per cent. to the one engine will be reduced in proportion to the ratio of that one engine to the total dealt with by the condenser; and, of course, a change in the record which comes from some unknown effect cannot be located so quickly. A fault may have arisen in some one engine, or it may be in two engines. Still the recorder does point to the fact that there is a fault to be found. Knowledge of its presence should be an incentive to finding it. Again, where several engines use the same condenser, say A, B, C, D, and three are at work, one being spare, the recorder will show the difference between any combinations of three, say A B C, A C D, B C D, and so on, and it may be found in this way that one engine is really too wasteful to be permitted to run.

In a cotton mill the load is so very steady that the recorder should be useful in the way of testing different oils or the best ratios of mixtures. It is well known that lubricating oils have great influence in cotton-mill work, for practically all the power of the engine is dissipated in friction. Almost nothing goes into the manufactured article—merely a slight torsional effect in the twisted fibres.

A customary form of recorder is shown in Fig. 1. It consists of a tank about 5½ft. long, with a middle division extending nearly to the bottom. The air-pump discharge enters the first division above a perforated horizontal plate which checks the turbulence of flow. The water is freed from air in this first division, and flows under the division plate to the second division, one side of which contains the notch—a clean-cut, sharp-edged plate of gunmetal. The float chamber may be placed for compactness in the first division of the trough or tank, or it may be placed at any convenient distance. In either case it is connected to the notch chamber by a pipe of such a size as to allow free water communication, yet small enough to throttle off sudden fluctuations. The adjustment of the apparatus is simple: the recording pen is adjusted to zero when the water in the notch chamber just runs over at the point of the **V**. The pipe connection to the float chamber is taken from a point as far as possible from the notch, so that the full head over the notch is shown by the float.

Since water increases its volume with temperature, the weight flowing hot over a notch will be less than would appear from the volume. But since the float expands less than the water, it sinks deeper in warmer water, and this action partially compensates for temperature error. Thus within the ranges of practice the instrument is very closely accurate. When applied to measure the outflow of jet condensers, the custom is to have several notches side by side, and the steam consumption can only be found indirectly by measuring the rise of temperature of the water, and calculating the proportion of steam that has entered it; or it might happen that the water could be also measured as it flowed toward the condenser, and the steam added would be the difference of the fore and after recorders.

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INDUCTION MOTORS IN CASCADE.

The following notes are from an article by Mr. H. C. Specht, in a recent number of the *Electric Journal*. They give a clear idea of the principles underlying the "cascade" method of operating alternating-current motors which is now coming to the fore, and which will certainly be very widely adopted for heavy power, variable speed, electric motor service in future. The method of varying the speed of induction motors most generally known is that of inserting resistances in the secondary circuit. The great disadvantage of this method is that any change in load, with a given amount of resistance in the secondary circuit, results in a variation of speed, and, if the load is removed, the motor returns to its original speed. Hence, for each given load and speed a different amount of resistance is required. In addition to the above disadvantage of this method, these changes in speed are accompanied by changes in efficiency; the lower the speed the lower the efficiency, and *vice versa*.

For cascade connection the induction motors are usually of the slip-ring or wound secondary type; the last motor of the set may, however, be of the squirrel-cage type. The rotors of all the motors forming the set are either assembled on the one shaft or their shafts are direct-coupled. The primary of the first motor of the series is connected to the supply circuit; its secondary is coupled to the primary of the next motor of the series (which may be the stator or the rotor), and so on. The secondary of the last motor is either completely short-circuited or connected to an external resistance. The maximum number of speeds which can be obtained by the various connections of a cascade set consisting of two single-speed motors is *four*. Referring to Fig. 1, when either motor *I* or motor *II* is running with its secondary short-circuited and its primary connected to the line, *i.e.*, operating as a single motor, the synchronous speed obtained corresponds to that of this particular motor and equals $\frac{\text{alternations}}{\text{poles}}$ and, under load, equals $\frac{\text{alternations}}{\text{poles}} \times (1 - \text{slip})$.

If the two motors are connected in direct concatenation a speed will be obtained which is equal to $\frac{\text{alternations}}{p_1 + p_2}$ in which p_1 = number of poles of motor *I* and p_2 = number of poles of motor *II*. If the two motors are connected in differential concatenation a speed will be obtained which is equal to $\frac{\text{alternations}}{p_1 - p_2}$. For example, if motor *I* has twelve poles and motor *II* four poles, and if the frequency of the line is 25 cycles, or 3000 alternations, the following synchronous speeds will be obtained:—

1. Motor *II* running single; $\frac{25 \times 120}{4} =$ 750 r.p.m.
2. Motors *I* and *II* in differential concatenation; $\frac{25 \times 120}{12 - 4} =$ 375 r.p.m.
3. Motor *I* running single; $\frac{25 \times 120}{12} =$ 250 r.p.m.
4. Motors *I* and *II* in direct concatenation; $\frac{25 \times 120}{12 + 4} =$ 187.5 r.p.m.

Two motors are said to be connected in direct concatenation, Fig. 1, when they have a tendency to start up in the same direction. In this case both machines act as motors. They are said to be connected in differential

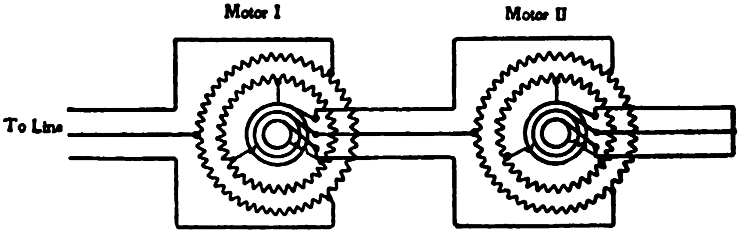

Fig. 1.

concatenation, Fig. 2, when they tend to start in opposite directions. In this case the second motor, *i.e.*, the motor whose primary is connected to the secondary of the first motor, acts as a frequency changer and generator. If motor *I*, having the greater number of poles, is connected to the line, then motor *II* is producing a rotating field in the secondary of motor *I* opposite to that of its primary. If motor *II* is connected to the line, its effect is to boost the frequency in the circuit connecting the two motors. This makes it possible to obtain a speed which is higher than the speed of motor *I* running as a single motor. In a three-speed cascade set motor *II* may have a squirrel-cage rotor if a constant resistance in the secondary is permissible.

In some cases more than four different speeds are required, in which case other schemes have to be employed. For this purpose a three-motor cascade set may first be considered. If motor *I* has fourteen poles, motor *II* six poles, and motor *III* four poles, by means of different connections the following synchronous speeds can be obtained, operating on a 60-cycle circuit:—

1. Motor *III* running single; $\frac{60 \times 120}{4} =$ 1800r.p.m.

2. Motor *II* running single; $\frac{60 \times 120}{6} =$ 1200r.p.m.

3. Motors *I* and *II* in differential concatenation; $\frac{60 \times 120}{14 - 6} =$ 900r.p.m.

4. Motors *I* and *III* in differential concatenation; $\frac{60 \times 120}{14 - 4} =$ 720r.p.m.

5. Motors *I* and *II* in differential concatenation, and motors *II* and *III* in direct concatenation; $\frac{60 \times 120}{14 - 6 + 4} =$ 600r.p.m.

6. Motor *I* running single; $\frac{60 \times 120}{14} =$ 514r.p.m.

7. Motors *I* and *II* in direct and motors *II* and *III* in differential concatenation; $\frac{60 \times 120}{14 + 6 - 4} =$ 450r.p.m.

8. Motors *I* and *III* in direct concatenation; $\frac{60 \times 120}{14 + 4} =$ 400r.p.m.

9. Motors *I* and *II* in direct concatenation; $\frac{60 \times 120}{14 + 6} =$ 360r.p.m.

10. Motors *I*, *II*, and *III* in direct concatenation; $\frac{60 \times 120}{14 + 6 + 4} =$ 300r.p.m.

By the above method a great number of speeds can be secured, but nevertheless such a method is not practicable. A motor set of this kind would be rather expensive and there would be difficulty in changing over from one speed to another. A much cheaper method and one superior in regard

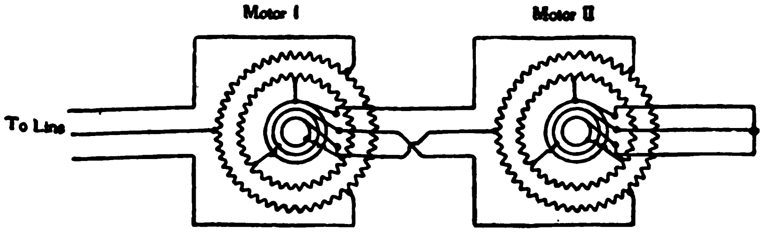

Fig. 2.

to change of speed is a cascade set consisting of one single-speed motor and one two-speed motor, or consisting of two two-speed motors. For example, with motor *I* having fourteen poles and motor *II* four and eight poles, the following synchronous speeds can be obtained when the set is operated from a circuit having a frequency of sixty cycles.

1. Motor *II* running single on four-pole connection; $\frac{60 \times 120}{4} = 1800$r.p.m.

2. Motors *I* and *II* with eight-pole connection in differential concatenation; $\frac{60 \times 120}{14 - 8} = 1200$r.p.m.

3. Motor *II* running single on eight-pole connection; $\frac{60 \times 120}{8} = 900$r.p.m.

4. Motors *I* and *II* with the four-pole connection in differential concatenation; $\frac{60 \times 120}{14 - 4} = 720$r.p.m.

5. Motor *I* running single; $\frac{60 \times 120}{14} =$ 514r.p.m.

6. Motors *I* and *II* with four-pole connection in direct concatenation; $\frac{60 \times 120}{14 + 4} =$ 400r.p.m.

7. Motors *I* and *II* with eight-pole connection in direct concatenation; $\frac{60 \times 120}{14 + 8} =$ 327r.p.m.

If the cascade set were made up of two two-speed motors the maximum number of speeds which could be obtained would be twelve. All the foregoing combinations of speeds are based on the assumption that the rotors of the motors are either on the same shaft or direct-coupled to each other. In some cases, and particularly in a cascade combination consisting of two single-speed motors, it might not be possible to obtain the exact speeds which are desired, that is, some of them might be the ones desired while the remainder would not be. In such a case the mechanical inter-connection of the motors might be made through gears or chains, belts, &c., with some other ratio than one to one. Assuming, for example, that speeds of 1075, 940, 500, and 340r.p.m. are desired, and that the frequency of the line circuit is 25 cycles; the closest speeds which could be obtained by a cascade set consisting of two single-speed motors, the rotors of which were directly connected, are 1500, 750, 500, and 375r.p.m. The corresponding number of poles would be six in motor *I* and two in motor *II*. The exact speeds which are desired could be obtained by connecting the two motors by means of gears or other devices giving decrease of speed in the ratio 2.8 to 2 and furnishing power from the shaft of the motor with the six poles. This mechanical connection would amount to the same thing as having both motors on the same shaft, *i.e.*, the cascade set would then be equivalent to a cascade set of which motor *I* has six poles and motor *II* 2.8 poles. The no-load speeds for the different connections would then be as follows:—

1. Motor *II* running single; $\frac{3000}{2.8} =$ 1071r.p.m.

2. Motors *I* and *II* running in differential concatenation; $\frac{3000}{6 - 2.8} = 938$r.p.m.

3. Motor *I* running single; $\frac{3000}{6} =$ 500r.p.m.

4. Motors *I* and *II* running in direct concatenation; $\frac{3000}{6 + 2.8} = 341$r.p.m.

The different schemes for possible speed combinations in a cascade set having been described, the performances at the different speeds will be considered. Two motors connected either in direct or differential concatenation may be considered, electrically, as if they were connected in series—that is, with the stators and rotors of both motors designed for the same voltage, approximately the same current will flow through each member. In case of lower power-factor the current in each member will differ somewhat; the current in the primary

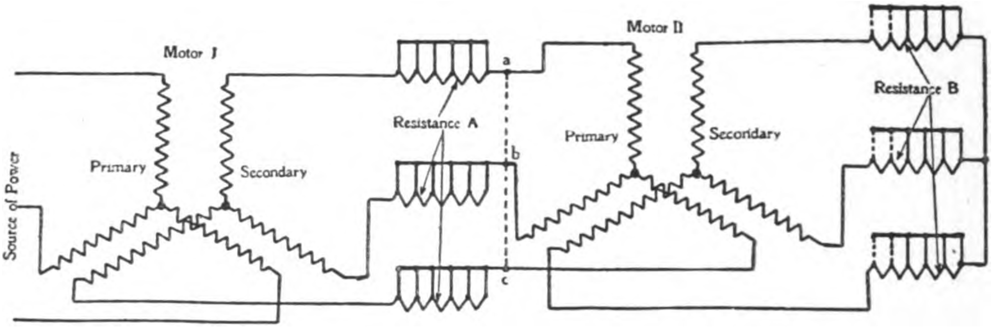

Fig. 3.

of motor *I* will be highest, that of its secondary (which at the same time is the current of the primary of motor *II*) will be lower, and the secondary current of motor *II* will be lowest. The lower the power-factor, the greater will be the difference between the currents. The conclusion to be drawn from the above is that the total magnetising current for motors in concatenated connection is equal to the sum of the magnetising current of the individual motors whether they be connected in direct or differential concatenation, *i.e.*, the total magnetising current is the same; and, furthermore, the reactance or leakage with the motors connected in either direct or differential concatenation is equal to the sum of the reactances of the separate motors. From these two facts it is clear that the power-factor and maximum output is lower with concatenated operation than by having motors operating independently. Therefore, a cascade set is generally more expensive than one single-speed or two-speed motor, and for this reason the application of cascade sets is somewhat limited; but, nevertheless, in many cases the required number of speeds cannot be obtained by other means without complications and without running the cost higher than, or at least as high as, that of the cascade set. Further, in a good many cases the conditions of operation are of such a character that the cascade set is superior to the other schemes.

As a rule the operation and control of the cascade set is simple and safe. For example, several speeds can be obtained without breaking the main circuits. This has a great advantage over any multi-speed motor in which the changes in speed require opening of the main circuit before the new connection can be made, unless choke coils or other complications are employed. Particularly on motors of large capacity or of high voltage the opening and closing of the main circuits is very undesirable.

The diagram, Fig. 3, shows the connections of a cascade set in which two speeds can be obtained in a very simple manner without breaking any of the main circuits. The full lines represent the connections when the motors are operating at low speed, *i.e.*, in direct concatenation, with some resistance in the secondary circuit of motor *II*. When the motor set is to be run at a higher speed the resistance at *B* will be short-circuited; the short-circuiting connections on resistance *A* will be opened step by step; the points *a*, *b* and *c* will be short-circuited, and finally resistance *A* will be short-circuited to the point giving the desired speed. The change from high speed to the low speed is accomplished by reversing the above operation. It is obvious that with this method of control the changing from one speed to another can be done in a very smooth and safe way without opening any of the main circuits. It is possible to obtain a greater number of speeds without adding greatly to the complication of the connections and still keep the main circuits closed throughout.

In order to obtain some idea of the simplicity of the control of the different combination in a cascade set, the number of motor leads which are required for three-phase cascade sets consisting of two motors is given below:—

1. Cascade set in which motor *I* has a wound rotor and motor *II* a squirrel-cage rotor; nine leads are required and a maximum of four speeds is possible.

2. Cascade set in which each motor has a wound rotor; 12 leads are required and a maximum of four speeds is possible.

3. Cascade set in which motor *I* is a single-speed wound-rotor type machine and motor *II* is a two-speed squirrel-cage motor; 12 leads are required and a maximum of seven speeds is possible.

4. Cascade set in which each motor has a wound rotor and motor *II* is a two-speed motor; 18 leads are required and a maximum of seven speeds is possible.

5. Cascade set in which motor *I* is a two-speed motor with wound rotor and motor *II* is a two-speed squirrel-cage motor; 18 leads are required and a maximum of 12 speeds is possible.

6. Cascade set in which each motor is a two-speed motor with wound rotor; 24 leads are required and a maximum of 12 speeds is possible.

As compared with the above a single multispeed motor requires leads as follows:—

1. Ordinary two-speed motor with squirrel-cage rotor; pole ratio 1 : 2; at least six leads are required, and for a motor with wound rotor twice as many.

2. Four-speed motor with squirrel-cage rotor; 12 leads or more are required, and for a motor with wound rotor at least 24 leads are required.

3. Six-speed motor with squirrel-cage rotor, having 4, 6, 8, 12, 16, or 24 poles; at least 48 leads are required, and for a motor with a wound rotor, 96 leads. The number of leads increases with the number of poles.

The above figures show that the multi-speed motor requires a much more complicated controller or switching device than the cascade set.

In addition to the forgoing it may be of interest to discuss the torque of cascade sets, both initial and running. The amount of total torque which can be obtained from a cascade set at the same real input and primary losses is equal to that of a single motor with the same synchronous speed, *i.e.*, the torque for cascade sets may be expressed as follows:

$$\text{Torque (in lbs. at one foot radius)} = 32.7 \times (\text{real input} - \text{prim. losses}) \times \frac{\text{poles}}{\text{cycles}}.$$

For example, if the motors of a cascade set are starting or running in direct concatenation, lbs. torque at one foot radius $= 32.7 \times (\text{real input} - \text{prim. losses}) \times \frac{p_1 + p_2}{\text{cycles}}$. When motors are connected in differential concatenation, lbs. torque at one foot radius $= 32.7 \times (\text{real input} - \text{prim. losses}) \times \frac{p_1 - p_2}{\text{cycles}}$. This shows that for the least input of energy the highest torque is obtained when motors are connected in direct concatenation, and this connection is therefore most suitable for high starting torque with the least amount of energy.

The torque developed by each motor of a cascade connection is proportional approximately to the ratio of its number of poles to the total number of poles of the set, multiplied by the total torque. Thus, with two motors connected in direct concatenation, one having ten poles and the other four poles, the torque developed by the first motor will be $\frac{10}{14}$ of the total torque of the set and that of the second motor will be $\frac{4}{14}$. With differential concatenation, the torque of each motor will be the same, but as they act in oppostion, the total resultant torque will be proportional to the ratio of the difference of the number of poles. Thus, with the motors considered above, the total torque with differential concatenation would be equal to $\frac{10-4}{14} = \frac{3}{7}$ of the torque developed by the motors when connected in direct concatenation.

The differential concatenation gives, in general, the lowest starting torque, and, moreover, if the motor having the greater number of poles is connected to the line, the motor set will not come up to its synchronous speed by itself. It will reach the synchronous speed of the single motor which is connected to the line and will not exceed this speed. Therefore it will be necessary to connect the motor having the smaller number of poles to the line, and when the set has nearly reached full speed value for differential connection, to switch over to the normal connection, *i.e.*, having the motor with the greater number of poles connected to the line.

It should be mentioned that, if neither of the two motors has a less number of poles than that given by the difference between the number of poles of the two machines, the speed of the differential concatenation cannot be obtained without the set being speeded up by separate drive or other auxiliary means; *i.e.*, the synchronous speed of the single motor which is connected to the line should be higher than the speed which is to be obtained by differential concatenation. In most cases it is not advisable to leave the motor having the smaller number of poles on the line because the frequency in the circuit connecting the motors will be of higher magnitude. The total iron losses of the set would, therefore, be considerably greater, causing a drop in the efficiency and also causing a higher temperature rise. In a case where a higher iron loss is not objectionable, the motor with the smaller number of poles may remain on the line.

THE WETTERHORN ELECTRIC CABLEWAY.

An interesting mountain transport system has recently been put into operation on the Wetterhorn mountain in Switzerland. As will be seen from the illustrations, this consists of an aerial cableway or telpherage system, the peculiarity of which is the extreme gradient of the line. Whilst the height of the Wetterhorn peak is 12,150ft. above sea level, the completed cableway covers only a portion of the ascent. Starting from the lower station at the Wetterhorn hotel, it ascends 1377ft. to the upper station. Fig. 1 shows the profile of the line, the vertical projection being 1377ft., and the horizontal projection 1197ft. The altitude of the upper station is some 6900ft. above sea level.

The cableway is constructed on the Feldman system, which consists essentially of two sets of double-trolley cables, one above the other, the upper ends being securely anchored and the lower ends passing round a loose sheave attached to a chain provided with a counterweight of 18.5 tons, suspended in a pit and maintaining the cables in tension. The main cables are about 2in. in diameter, consist of ninety-six strands in five layers, and weigh about 22lb. per yard. The running conditions of the line demand a tensile strength of 13.8 tons, whereas tests have shown the cables to have a breaking strength of 154 tons.

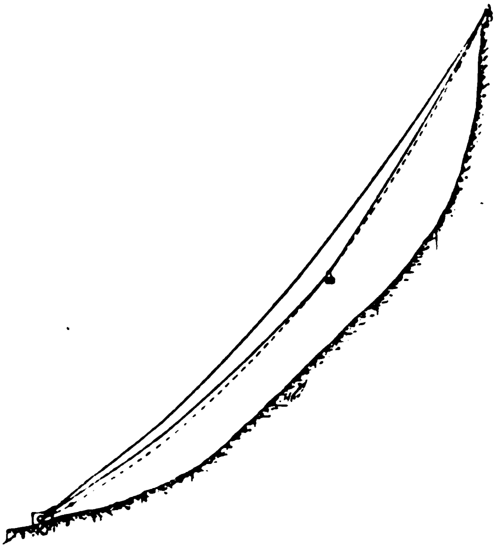

Fig. 1. Profile of the Wetterhorn Cableway.

These main cables form the runway of trolleys from which the passenger cars are suspended; the trolleys being drawn up and lowered by means of hoisting cables. The hoisting cables consist of a 90-strand steel hawser, about one and one-eighth inch in diameter. They work under a safety factor of 17.5, the working load being 2.5 tons, whilst the test tensile strength amounts to 43.75 tons. As will be seen from the illustration, Fig. 2, there are two of these hoisting cables for each trolley.

The upper works of the line are clearly shown in Fig. 3. The vertical distance between the pair of main cables of each way is 2.9ft. and the distance between the two lines is 26ft. The upper station consists of a heavy concrete foundation built against the side of the mountain in step form, the entire mass of the foundation and the machinery and the structural work of the station being set well back with respect to the point of suspension of the main cables, so that it acts as a huge counterbalance or anchorage opposing the pull of the cables. The hoisting machinery, shown in Fig. 4, consists of two sheaves, 12.13ft. in diameter, each having six grooves for the hoisting cables; that is, three grooves for each cable. The pair of cables for each trolley pass over guide sheaves 9.8ft. in diameter to the main

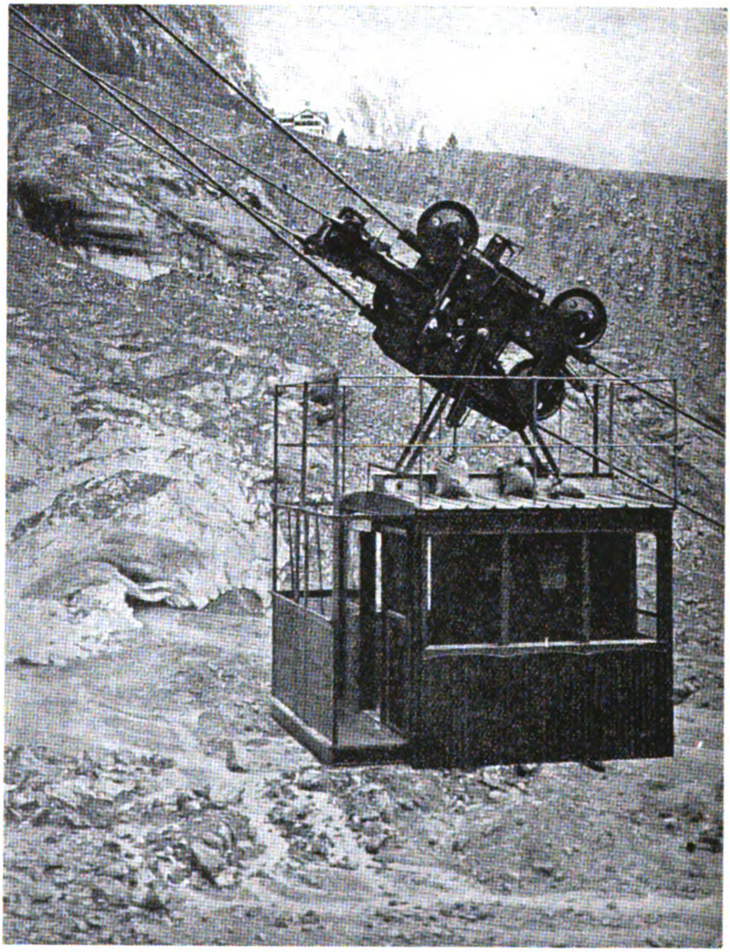

FIG. 2. CAR AND TROLLEY ON THE WETTERHORN CABLEWAY.

sheaves, passing a half-turn round each of the main sheaves. The hoisting gear is driven through gearing by a 45h.p. shunt-wound Brown-Boveri electric motor. The control apparatus of the motor has been very carefully arranged both for automatic and hand operation, to ensure perfect safety: an automatic brake is provided for locking the gear should the current supply fail; further automatic devices ensure the car entering the station at a low speed and prevent overwinding. The speed of the motor is under manual and automatic control. There is also a hand brake for bringing the car definitely and gently to rest at the station platform, the current being automatically cut off the motor when the car is within 13ft. of the landing platform. The current supply is obtained from Grindelwald at 2400 volts single-phase; this is converted in a substation at the lower end of the line by motor generator to 800 volts direct-current. A storage battery of 74amp.-hours capacity, sufficient for twenty-five journeys, is installed as a stand-by and provisions are also made for the manual hauling of the cars to the stations in case of entire failure of the electric system.

One of the most important and at the same time most difficult features of the equipment was the provision of a safety braking device, which should come into operation should the hoisting cables part. A mechanical arrangement ensures that should either of the hoisting cables break, springs force a pair of split conical grips against the main cable and lock the trolley at a stand-still. Repeated tests proved the efficacy of this device, the car coming to rest in a distance of 10in. after the brake-springs were released. Whilst the cable makers demurred at the excessive strain likely to be thus thrown on the cables, it was shown that no serious jerk was imposed by this sudden braking, the sag of the cable length acting as an effective buffer. The

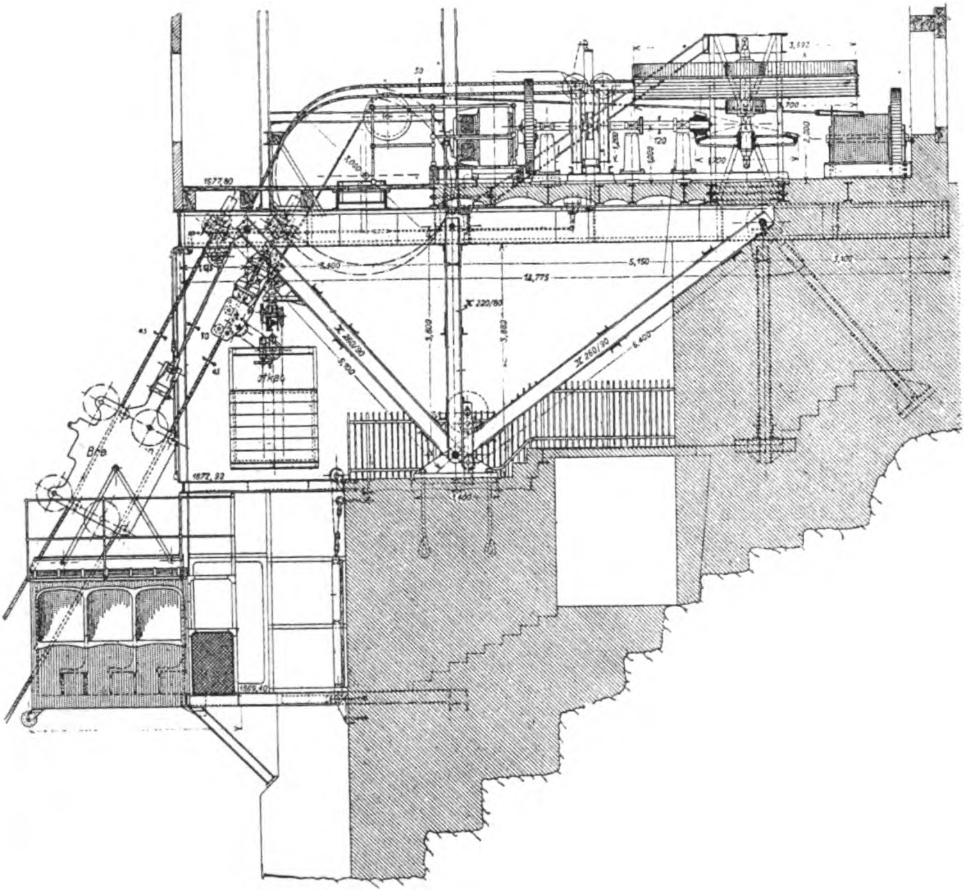

Fig. 3. Details of the Upper Station.

automatic brake having come into action can only be released by a special tool. In the event of the release failing to act or the trolley for some other reason becoming fixed there is provided for each cableway a small auxiliary car operated by a separate 8h.p. hoist and capable of carrying four or five persons.

The general construction of the four-wheel trolley and the car and its suspensions is shown in Fig. 2. The car is 10.5ft. wide by 8.2ft. long, divided down the centre to give a slot for clearing the main cables; the gradient of the line as the car approaches the upper station, is about 200 per cent., and the cable slot thus requires to run practically the entire length of the car. Each car has seating accommodation for eight, and standing room for as many more. The conductor's platform at the front end is 2.7ft. wide, and as will be seen from the illustration, the top of the car is railed in to give security to the operator should inspection of the trolley be necessary. The car complete with its trolley weighs 4.1 tons empty.

The whole system was subjected to very stringent tests by the public authorities before being passed for public service. It is now in constant use, and will rank as a great achievement, being the first of its kind. The entire work of construction was carried out

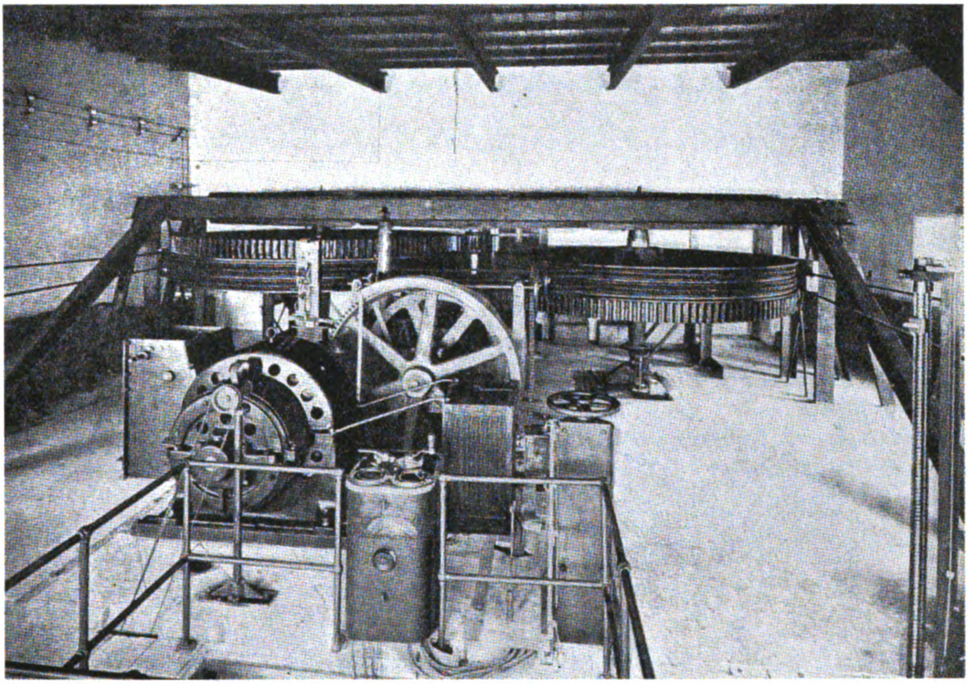

Fig. 4. The Electric Hoisting Plant.

by L. von Roll's Eisenwerke, Gerlafingen, Switzerland. The installation described forms only the first section of the system; and it is certain that not only on the Wetterhorn but on many other of the peaks favoured by tourists extensions of this cableway means of mountain climbing will become general, the superiority of the electric cableway as compared with mountain railways in the matters of first cost and maintenance being obvious, not to mention the fact that as a comfortable and yet sensational mode of crossing the Alps the new system will become immensely popular.

THE WORLD'S PROGRESS IN ELECTRICAL AND GENERAL ENGINEERING.

The Montreal Sub-station.

In view of the present tendency towards the absorption of municipal supplies of electricity into the power-in-bulk systems which have become such a feature of British practice within recent years, an example from Canada, as seen in the Shawinigan Falls Power Company's supply to Montreal, is of interest The high-tension supply current at 12,500 volts pressure is stepped-down at the Montreal sub-station to a pressure of 2400 volts by means of Westinghouse transformers, and the power so obtained, to the extent of nearly 10,000kw., is distributed in the form of direct current through the medium of rotary-converters and motor-generator sets constructed by the Allis-Chalmers Bullock Co. The capacity of the sub-station plant amounts to 15,700kw. installed, there being five motor-generator sets each of 1000kw. capacity, two 4000kw. motor-generators, and three 900kw. rotary

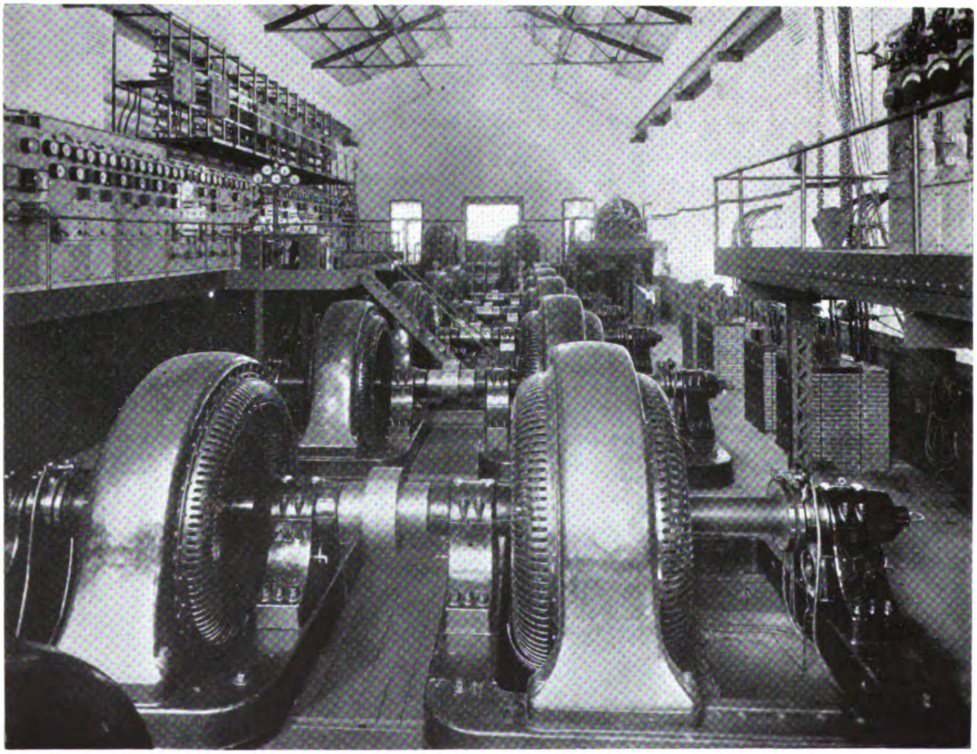

FIG. 1. THE SUB-STATION OF THE SHAWINIGAN WATER AND POWER COMPANY, MONTREAL.

converters for traction service. In addition to the main power units as mentioned there are two 300kw. exciter sets consisting of induction motors direct coupled to continuous-current generators yielding current at 125 volts pressure.

The illustration, Fig. 1, shows the group of five 1000kw. motor generators, and, at the far end, one of the 4000kw. sets. These are of the usual horizontal type, consisting of 30-period synchronous motors direct coupled to alternate-current generators giving three-phase current at a frequency of 60 periods per second. Fig. 2 gives a nearer view of the 4000kw. sets. These, together with a vertical frequency changer of the same capacity, are the largest frequency changers at present in operation. The vertical set is particularly interesting. The generator gives three-phase power at 2300 volts and 50 periods per second. It is run up to speed by a small induction motor mounted on the same shaft and vertically above the main machine. The rotors of the machine, carried on the vertical shaft, are supported by a roller bearing. This runs in oil, and its duty is gauged by the fact that it supports a weight of about 100,000lb., rotating at 450r.p.m.

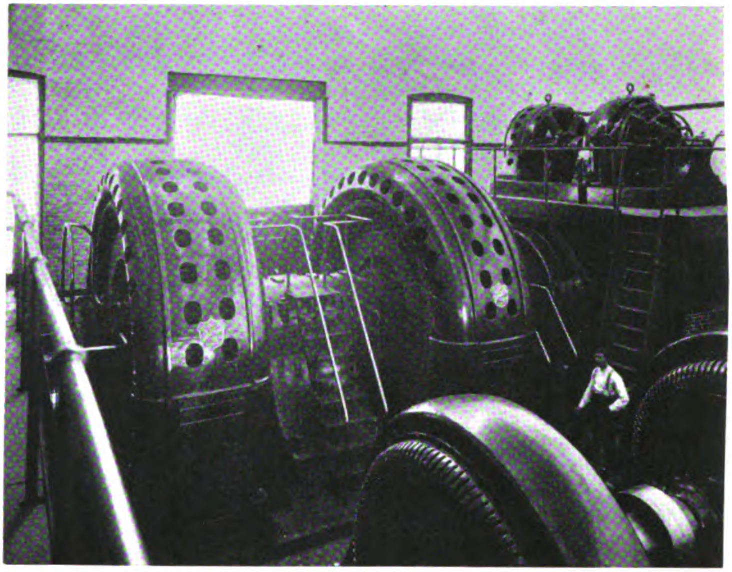

FIG. 2. A 4000KW. FREQUENCY CHANGER, MONTREAL SUB-STATION.

A portion of the switchboards of the sub-station is shown in Fig. 1. It will be seen that this is a fine example of modern switchboard work. The main board is about 90ft. long, and consists of forty panels; the rotary converter board includes a further sixteen panels. The whole equipment is a very interesting example of large sub-station practice.

11,200h.p. Turbo-Alternator.

THE large power house now under construction at Buenos Aires is to be equipped with ten 7500kw. Parsons-Brown Boveri turbo-dynamos. Five of these large units have been ordered, viz: four sets of turbines each driving one 7500kw. three-phase alternator, and one set driving two three-phase generators in tandem, each having an output of 7500kw.

The turbine of the last mentioned is capable of developing 11,200h.p. at 750r.p.m., and will carry an overload up to 14,200h.p. for two hours. Steam is supplied at 180lb. pressure with high superheat, and the guaranteed full load steam consumption with cooling water at 15deg. C. is 13.85lb. per kw.-hour. One of the two generators is rated to give 8350k.v.a. output at 12,000 to 13,000 volts, 25 period, while the other is designed to give 8825k.v.a. at 12,500 volts, 50 periods. An exciter is built on the main shaft and has an output of 110kw. at 220 volts.

The surface condenser of the set has a cooling surface of 14,000 sq. ft., and can deal with 100,000lb. of steam per hour. With cooling water at 15deg. C. a vacuum of 95 per cent. (28½in.) is maintained; at 25deg. C. the vacuum would be 91 per cent., or 27¼in. The high-pressure and the low-pressure sections of the turbine are divided by a bearing so that only the comparatively small high-pressure turbine is subjected to the high temperatures of superheat and the consequent possible expansion variations, thus the risk of stripping the low-pressure blades is minimum. Contrary to Parsons' usual practice the double-seated steam admission valve is not operated by steam but by oil. As this pressure oil supply also forms part of the pressure lubrication system, any failure of the latter shuts down the turbine. The safety governor shuts off the main stop valve when the speed exceeds the normal by 15 per cent.

The rotors of the alternators are of the cylindrical type and they weigh 25.3 tons each; each stator weighs 48 tons without bedplate. The weight of the complete set, including the surface condenser plant, is about 475 tons.

* * *

Trade in the Argentine Republic.

THE ARGENTINE offers at the present time one of the most important foreign markets for British engineering machinery. The Republic is progressing at a very rapid rate, and is being opened up and developed in all directions. In addition to the Government, there are twenty-two companies owning railways; the Government lines include 1838 miles of track, whilst the companies control 11,908 miles. This total is nearly 2000 miles in excess of that of the lines in operation last year, and the extension of the railways is still proceeding rapidly in various districts. The Ferro Carril Norte Argentino is constructing a new line from Rosas to Casta Sacate; the Central Railway is putting down three new sections of lines; the Buenos Ayres-Rosario line is about to be extended; and the Southern Railway is now carrying out extensions amounting to about 830 miles of track, which will bring their line through to connect with the Chilean system across the Cordilleras. The profits earned by the several railways last year amounted to about £6,000,000, so that there is every encouragement towards increased development.

The tramways systems of Buenos Ayres, controlled by seven companies, include nearly 400 miles of track, and they are being constantly extended. Apart from the ever-present demand for track equipment supplies, rolling stock, and usual electric tramways specialities, there is a wider field opening up in connection with the proposal to construct an underground electric railway to connect the city with the port.

The port of Buenos Ayres is to be enlarged, and a deep-water canal cut to connect the city with the Porosa river. For this work the Government has voted a sum of about £10,000,000. A further grant of about £6,000,000 has been made for similar work—the construction of a port at the mouth of the Quequen Grande river, and the improvement of the water-way of the Gualeguaychu river.

Of the general industries of the country the most prominent, from the British engineer's point of view, are the mining and the textile trades. In the former case, although there are many companies, engaged chiefly in copper, silver, and lead getting, they are mainly using antiquated plant, and the necessity for up-to-date machinery is being experienced. The prospects of textile machinery makers are brightened by the increased extent to which fibre-producing plants are being cultivated.

Naturally, with the growth of these great industries, there is a correspondingly good demand created for the smaller classes of supplies, and the British manufacturer generally should not neglect this market, which holds out such fine opportunities for a large and profitable export trade. Germany, France, and the United States are already in the field as strong competitors, but British products are called for, and in many instances are given the preference.

* * *

Condensers for Electric Power Circuits.

It is a well-known fact that, although the use of condensers in connection with alternating-current plant is admittedly desirable, their adoption has been extremely limited. This has been partly due to the difficulty experienced in constructing a reliable condenser which at the same time would not be too costly nor occupy an undue amount of space. A description of a new construction by Messrs. Meirowsky & Co., which promises to avoid some of the principal inherent defects of condensers for power purposes, appeared in a recent number of the *Elektrotechnische Zeitschrift.* This firm designed a machine which, although originally intended for making tubular insulators, turned out to be very suitable for making electrical condensers.

The process of making insulators by the machine is briefly as follows:—Specially prepared paper, mounted on a reel, is drawn off and wound tightly on to a spindle, the reel being suitably braked to keep the paper in tension. On its way to the spindle the paper strip is dried by contact with hot iron plates, and the winding spindle rotates between two heated iron rollers which press the paper tightly against the spindle. These hot rollers serve to extract the last traces of moisture in the paper, and owing to the intense pressure the air is removed from between the layers. When the winding has been completed the roll can be removed from the spindle, and owing to its treatment the paper, dried and compressed, forms a solid cylinder somewhat of the consistency of wood. By a special process these rolls or cylinders can then be pressed into shallow rectangular rings. The material thus produced has been known on the market for some years under the name of "Pertinax," and has proved itself as having good insulating qualities whether used exposed in air or immersed in oil.

To make a condenser on this principle, sheets of tinfoil are wound in with the paper at suitable intervals. The length of each sheet of foil is cut exactly equal to the circumference of the roll at the place where it is introduced. The width of the foil is made less than that of the paper in order to leave a suitable margin for insulation. Connecting strips for terminals are left on the sheets of foil running out of the coil lengthways, and are laid alternately to the right and to the left.

A tubular condenser of a solid and permanent construction is thus formed which has decided advantages over other forms. One great point is that the sparking troubles at the edges of the plates are entirely avoided, and the sheets of foil are completely enclosed. Air is excluded owing to the high pressure of the rollers. That the moisture is removed entirely will be evident when it is explained that the temperature of the rollers is not far removed from the melting point of the tin foil. These tubular condensers may be compressed into a flat shape for convenience in space occupied, although the inner cooling surface is thereby reduced.

Condensers for any pressure may be made in this way, as it is to be noted that the number of turns of paper between foils may be varied at will. Thus the distance between two plates is always a multiple of the circumference of the winding spindle. There is no limit to the thickness of paper that may be used, so that even for low pressures condensers may be made at a reasonable cost.

The electrical losses in these condensers are said to be small, being of the order of 1 per cent. The capacity rises considerably with the temperature. A test on a set of four condensers pressed flat gave the following average results:—Duration of test 5½ hours; average load 4·5amp., 1100 volts, 87 periods; average power consumption of condenser 49.5 watts. The room temperature of the air was 16deg. C.; inside the condenser the temperature rose to 37.5deg. C., while the surrounding air rose to 18deg. C. Under these conditions the capacity of the condensers rose from 8.70 to 9.30 microfarads. In practice this form of condenser has been used with success for driving three-phase motors with single-phase supply, and for other similar power circuit duties.

⁂

Coke Oven Gas Electric Plant.

THE largest coke-oven gas electric plant is said to be that of the Eschweiler Mining Company, near Aix-la-Chapelle, Germany. The first installation of this kind was started at these collieries in the year 1904, and the good results accruing since then have prompted the owners to extend the system. The original plant consisted of two 500b.h.p. engines direct-coupled to three-phase alternators. In 1904 and 1905 three additional larger sets were installed, these including two 1000b.h.p. engines and one 1200b.h.p. engine. The continued success of the plant prompted the owners to put down two sets each of 2500b.h.p. in 1907, and to order last year a further pair of 2600b.h.p. to 2800b.h.p. each. The total output of the plant thus installed is about 15,000h.p. The engines are all of the Nuernberg type, the larger sizes having twin-tandem cylinders.

Before the introduction of gas-driven electrical units the Eschweiler Mining Company used the coke-oven gas as fuel under steam boilers, and distributed the steam to numerous engines about the mines and works. With this now old-fashioned method only some 15 per cent. of the heat value of the gas is utilized as a maximum, whereas with the internal-combustion engine 30 per cent. of the calorific value of the gas is converted into useful power. The result is that with the same quantity of gas available the new method secures more than twice the power formerly obtained. As a matter of fact, the electric power now generated far exceeds the power of the adjacent works, and large quantities are being transmitted to other mines in the district. In one of these cases the three-phase current, at a pressure of 3500 volts, operates an Ilgner main winding system. Another important supply is to a pit about eleven miles away; the transmission in this case is at 35,000 volts, and some 3000h.p. is utilized for pumping and general auxiliary purposes in the mine. Another pit draws about 1500h.p. to 2000h.p. also for general power purposes.

Tests of the two 2400h.p. gas engine sets were made by Professor Lange, of the University, Aix-la-Chapelle, with the following results:—

	Test 1.	Test 2.
Output in kw. - - - -	1530	1554
Heat consumption guaranteed in B.t.u. per i.h.p-hour - -	8000	8000
Tested consumption in B.t.u. per i.h.p.-hour - - - -	6865	6862
Total efficiency, taking the efficiency of the alternator at 0.945 - - - - - -	0.794	0.794
Proved efficiency at full load -	0.844	0.857

An important feature of these tests was that the two sets were tried for parallel running under all conditions of load, and they demonstrated their thorough reliability for such service. One of the engines was also tested with producer gas made from coke, no alteration of the valves or governor being made from the original design and adjustment as for coke-oven gas working. It was proved that the engine worked equally well, without adjustment or modification and at full load, with coke-oven gas of 340B.t.u. to 450B.t.u., or with producer gas of 113B.t.u. per cubic foot.

Such results as these are all-important to colliery owners in this country, particularly those of the tests as to the capacity of the engines with widely varying qualities of gas, and reliable parallel running under very diverse load conditions with the alternators direct-coupled. It is mistrust and doubt on such points as these which have deterred many British colliery owners from putting down high-power gas-electric installations in spite of the undoubted and well-understood supreme heat-efficiency of such plants.

* * *

Accumulator Railway Cars.

It would seem that the use of electrically driven motor carriages supplied by means of accumulators, as tried on the Prussian State Railways, has proved a success, since a further thirty-three cars operating on this principle have been ordered recently for the Prusso-Hessian State Railways. This will make a total of ninety of these cars in use on this line alone; in addition to which there are a considerable number which have been running for the last ten years on the Bavarian Palatine lines.

* * *

Time Limit Device.

On many circuits liable to frequent momentary overloads, it is desirable to introduce a time element before the circuit breakers shall trip, thus giving continuity of service, without endangering the safety of the plant.

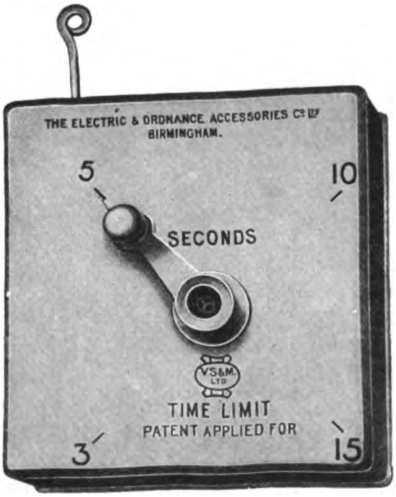

Fig. 1. General View of Time Limit Device.

The "Ordnance" time limit device consists essentially of a partially toothed quadrant gearing with an escapement, which allows the quadrant to move only at a certain speed until it becomes disengaged and so releases the breaker, or until the load becomes normal again.

The time element is practically constant for any pull; should it be desirable, however, to release the breaker instantaneously by a dead short circuit, the device can be fitted with an attachment to effect this end. This does not, of course, operate on ordinary overloads, the required time lag being introduced before the circuit breaker is released.

The general exterior appearance of the instrument is shown in Fig. 1, and Fig. 2 partially shows the interior. Fig. 3 is a "Cee-Bee" circuit breaker (2500 amp.) fitted with one of these time limits.

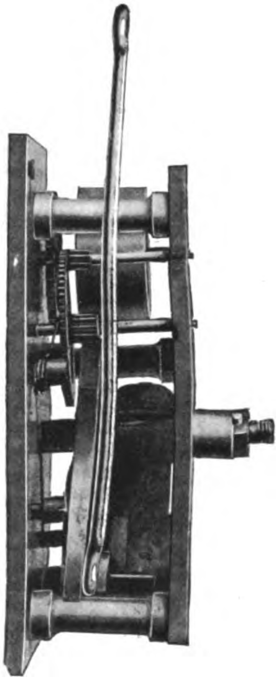

Fig. 2. Side View of Interior of Time Limit Device.

It will be seen by reference to Fig. 1 that the device is calibrated for four time lags, this being claimed as a feature unobtainable in any other time limit device at so low a price as the "Ordnance." This is quite an important part of the design, as it enables the user to choose any time limit the conditions of service may require at the time, and to alter it when he deems it advisable without reference to the manufacturers. The

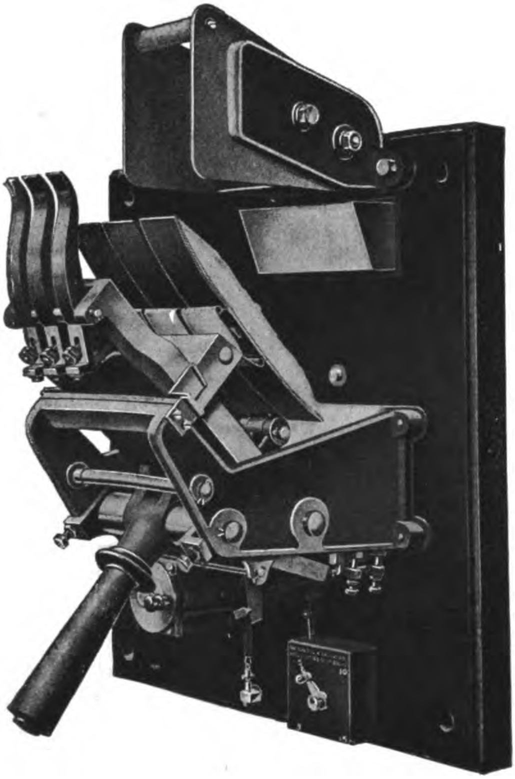

FIG. 3. TIME LIMIT DEVICE FITTED TO CIRCUIT BREAKER.

instrument, of course, can be calibrated for any other periods than those shown in the illustration. It is claimed for the instrument that it is extremely simple, compact, and reliable, and that it will always operate after the same interval of time to within a small percentage.

❧

Electric Postal Service.

IT is reported that the Austrian postal department are considering the installation of a system of light electric railways for the interchange of postal packages and letters between the general post office in Vienna and the sixty-four branch offices and nine railway stations of the city. The proposal is to construct an underground tunnel or tube system in which trains of eight cars each shall run on a twenty-minute service. The trains would be automatically controlled from the several despatching points, they would have an average speed of twenty miles an hour, and each of the cars would accommodate bags and packages equivalent to the average present horse-drawn van load. It is said that an electrical firm has offered to construct and equip the entire system at their own cost, and lease it to the city postal authorities. Should this system be brought into use it would displace the 700 horses and 450 vans which now serve for the distribution and collection of Vienna's mails.

❧

Peat and Iron in Canada.

SOME noteworthy reports have just been published by the Canadian Department of Mines. One of these deals with the nature and extent of some of the large deposits of peat which exist in the eastern part of the Dominion. The importance of the peat fuel industry to the central portion of Canada, where coal fuel is non-existent and its importation so comparatively costly, requires no demonstration. The Mines Branch of the Department of Mines, Ottawa, issued a year ago a report on "Peat and Lignite, their Manufacture and Uses in Europe," with the object of giving to Canadians as complete a review as possible of this industry in those countries in which it has been most successfully carried on. The report just out is entitled "The Investigation of the Peat Bogs and Peat Industry of Canada during the season of 1908-09," and comprises twenty-five pages of text and six large-scale maps of the following peat bogs: Mer Bleue, near Ottawa; the Alfred peat bog, about forty miles from Ottawa; the Welland peat bog, about six miles north of Welland; the Newington bog, on the New York and Ottawa Railway, and about forty miles from Ottawa; the Perth bog, a mile and a half from Perth; the Victoria Road bog, about a mile from Victoria Road station on the

Midland division of the Grand Trunk Railway. The matter includes a description of each bog, showing the situation, area, and structure, and giving an estimate of the available supply of peat fuel with records of analyses, calorific values, &c.; all of which should be of particular interest to those engaged in, or connected with, the development of Canadian peat resources. A fuel testing plant is now being erected at Ottawa, in which the value of peat for the production of power gas will be demonstrated, and the department proposes to carry on a very thorough investigation of this subject.

A second report deals with the iron ores of Nova Scotia and covers very thoroughly the more important iron deposits of the province. The report consists of 222 pages of text, 63 illustrative photographs, diagrams and maps, and a copious index. The scope and economic importance of the work may be judged from the detailed instructions given to the author, who was requested to give special attention to localities of iron ore deposits so far discovered, and names and addresses of owners; history of development of mines and companies; geological description; analyses of ores; in cases of mines which have been worked, output and statistics; transportation facilities; limestone in neighbourhood of deposits; a general statement as to forests in neighbourhood, *i.e.*, whether the supply is sufficient for mining purposes and for the production of charcoal in the event of the introduction of electric smelting; maps of mines and drill holes, if any. The report itself is divided into two main parts: Part I. deals with the geographic relations of the deposits, their mineralogy and geology, and questions relating to mining policy, bounties, and mining laws. Part II. is entitled "Details of Iron Districts," and covers more particularly the ores of the Clementsport basin, the Nictaux-Torbrook field, the deposits of Hants and Colchester counties, the ores of the Western Cobequid mountains and of Arisaig, and the ores of Cape Breton. This part is replete with analyses of ores, records of bore holes and geological sections, and other statistical data. A second volume, covering iron ore deposits not referred to in Volume I., and devoting special attention to limestones of value for metallurgical purposes, will shortly be issued. In view of the present condition of the iron ore industry of Canada, and particularly Nova Scotia, where so much imported iron ore is being used, this report should be of special value to mining engineers, investors and others interested in the development of the iron resources of the province.

❧

Large Chain Drives.

As indicating the rapid advance which is taking place in the use of chains for heavy power transmissions, the following illustrations are of interest. The Westinghouse Brake Co., Ltd., inform us that they

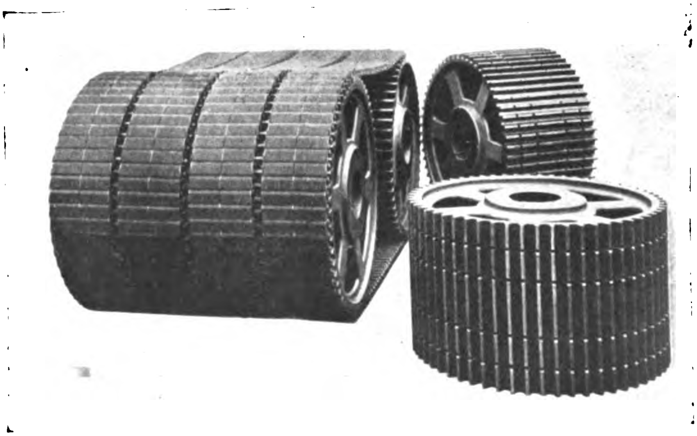

Fig. 1. A Heavy Power Chain Drive.

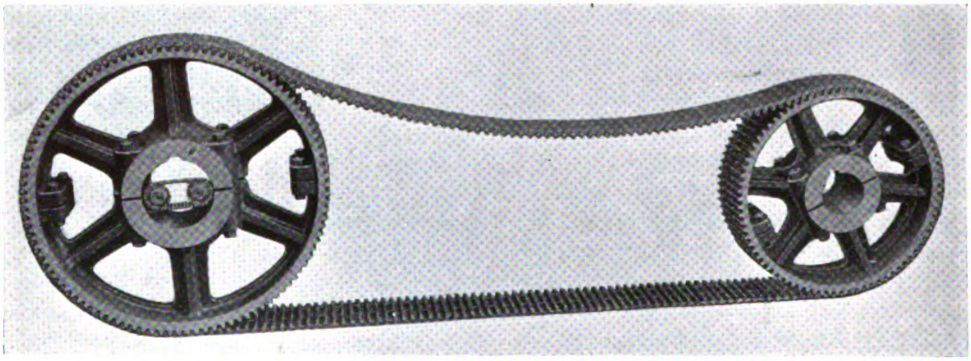

Fig. 2. A 300h.p. Chain Drive and a $\frac{1}{3}$h.p. Drive.

have just received an order for four of the drives shown in Fig. 1, this being a repeat order following the installation of seven similar equipments for the Kolomna Engine and Machine Works, of Russia. The leading particulars of the transmissions are as follows:—

Number of drives	7
Horse-power of each drive	500
Aggregate horse-power	3500
Outside diameter of wheels	37.784in.
Width of wheels	22in.
Pitch of chain	2in.
Width of each chain	10in.
Chain speed	1480ft. per minute.

Each of the drives consists of two 250h.p. chains, running on one pair of wheels. The great range of sizes covered by the makers of these chains is interestingly shown in the second illustration, which depicts a $\frac{1}{3}$h.p. drive inside the bore of the large wheel of a 300h.p. drive. The latter was supplied to the well-known "Kodak" photographic supplies manufacturers' Jamestown works, to drive an air compressor from a Corliss engine.

* * *

A New Tantalum Lamp.

A TANTALUM lamp of new rating has just been placed on the market by Messrs. Siemens. The lamp is for high-voltage service, direct-current, and is stated to give 25 candle-power at an efficiency of 1.7 watts per candle for all voltages between 200 and 240 volts. The general appearance of the lamp is similar to that of the 32c.p. high-voltage tantalum lamp, which is too well known to need comment. The new lamp, which is claimed to be strong and durable, should be a great boon to contractors who have hitherto been faced with the problem of supplying private consumers with a comparatively low candle-power lamp which would burn direct on high-voltage supply.

* * *

Electro-metallurgy at the White City.

THE exhibit of the Cowper-Coles Engineering Company at the Imperial International Exhibition is thoroughly representative of the activity of Mr. Sherard Cowper-Coles in electro-metallurgical research and practice. By means of specimens of work done, finished commercial products, and models of plant and process, the immense progress which has already been made and the great economical possibilities which rest in this branch of chemical engineering are made self-evident.

The manufacture of copper tubes, sheets, wires, and strips direct from the crude copper, without the interaction of smelting or any heating process, is probably the most important development, as being in regular use on a commercial scale and producing materials always in large demand. This

"Centrifugal" process, as it is termed, consists essentially of the electrical deposition of copper upon rapidly revolving mandrels. The friction of the electrolyte and the speed of the cathode allow of the use of heavy current densities, *i.e.*, very rapid rates of deposition, and the result is a highly-burnished close-grained uniform product, giving superior tensile tests to those obtained with the product of the older methods of smelting and rolling.

The electrolytic manufacture of iron is probably the most important of the later Cowper-Coles developments. Iron sheets and tubes are now prepared by this process direct from the ore, and the surface of the metal obtained is so good that no rolling or drawing is necessary. The anodes may either be of crude iron or the ore itself may be used in conjunction with insoluble anodes (graphite being used for this purpose) The iron ore is leeched in an acid solution which forms the electrolyte, and the metal is deposited on stationary or rotating cathodes according to the class of finished product required. It has long been known that iron can be electrically deposited: the great task has been to secure a hard close deposit at reasonable cost and of commercial value. The Cowper-Coles process is so far advanced that works are now being built on the Continent to make sheets and tubes on a large commercial scale. It is not necessary to indicate the vast importance which this process, as a proved success, will be to the world in general; the separation of iron without the use of fuel or furnace, but only requiring an electric supply, means the creation of industries in many now desolate parts of the world where rich ferrous ores abound, fuel is not, and waterfalls are within electrical transmission distances. Details of the Cowper-Coles method of iron manufacture are reserved for the present. We hope however to return to the subject and include a fully illustrated description in this journal at an early date.

Another recent invention of Mr. Cowper-Coles is in connection with the production of metallic mirrors with surfaces of alternate bands of gold and silver. It has been found that a gold mirror gives a far more penetrating beam of light than that reflected from a silver mirror. The combination of the two metals, therefore, gives a beam which is very penetrating and yet retains the valuable property required for searchlights for military purposes—the dazzling effect. For motor-car headlights gold mirrors are supplied; they show up distant objects very clearly and do away with the dazzling effect, which is so very objectionable a feature of the powerful car-lights now in vogue. A number of interesting metals which have been treated electrolytically are also exhibited: chromium, cobalt, platinum, and palladium and iridium; also specimens of electro-deposited alloys, such as cadmium and silver.

❧

Motor Starter for Printing Machines.

EVERY printers' engineer knows that the starting of electrically driven printing presses is hard on the switchgear because of the "inching" which is repeatedly necessary when preparing the press. When "inching" the minder starts up the motor and immediately stops it again, the object being to move the press forward a very short distance. This constant "inching" causes arcing on the contacts of the starting switch, with the result that the contact studs of ordinary starting switches soon wear out and renewals are required so frequently as to become a nuisance, as well as a serious expense.

To prevent this injurious arcing, all sorts of devices have been employed. The most successful is to use self-acting motor-starting rheostats, in which the motor circuit is always made and broken by means of a solenoid-controlled switch, which has carbon contacts for circuit breaking, as well as magnetic blow-out. For small flat-bed presses however, the initial cost of self-acting motor starters is often considered prohibitive.

With the object of rendering ordinary hand-operated starters suitable for this service, such devices as auxiliary carbon contacts, magnetic blow-outs, and interlocked solenoid switches, &c., have been employed. These devices are not altogether successful, because they have protected only the first step, whereas the machine minder, whose eyes must be on the machine and not on the starter, often pulls a handle, when inching, over to the third or fourth contact, or perhaps further, and in moving it back draws a destructive arc across the starter steps.

The illustrations herewith are of a new type of "Igranic" switch designed to give perfect protection of the starter contacts. It employs an interlocked magnetic circuit maker and breaker, and the essential merit of the arrangement consists in the fact that no matter how far the operator pulls the handle over in a forward direction, the slightest backward movement instantly opens the circuit-breaker. Consequently no arcing can occur on the starter steps because they are "dead." The circuit-breaker has carbon contacts and a magnet blow-out and will open the circuit an infinite number of times without receiving injury. With this starter, therefore, "inching" may be practised to an unlimited extent—in fact, a recent extended trial in a large printing works, under ordinary working conditions, left the contacts as good as new. In addition, the interlocking of the circuit-breaker with the starter makes it impossible to close the motor circuit, except with all the starting resistance in circuit, so that the motor receives proper protection and the starting switch may be said to be practically "fool-proof."

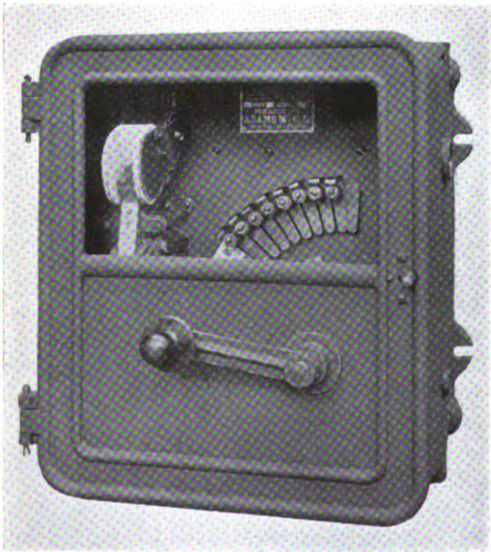

Fig. 1. Motor Starter for Printing Machines.

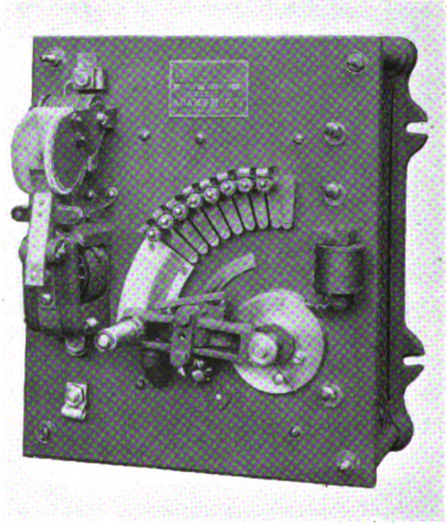

Fig. 2. Motor Starter for Printing Machines. Cover Removed.

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High-speed Reducing Gears.

THE increasing practice of providing each machine or tool with an independent electric motor, as distinct from group driving with its necessary lengths of countershafting, reducing pulleys, and belts, has called for special designs in the way of compact and self-contained speed-reducing gears of high speeds, and many firms now make and list such specialities. A neat arrangement of a reducing gear compactly assembled in an enclosing box and providing a second-speed shaft in line with the main higher-speed shaft, usually the electric motor spindle, is shown in the several illustrations herewith. This gear, known as the "Ross" patent speed-reducing gear, made by R. G. Ross & Son, of Glasgow, in its simplest form is composed of a central crank shaft or eccentric, carrying two pinions of different diameters, keyed together. These pinions gear respectively with an internal toothed wheel fixed to the casing, and an internal toothed driven wheel fixed to the slow-speed shaft.

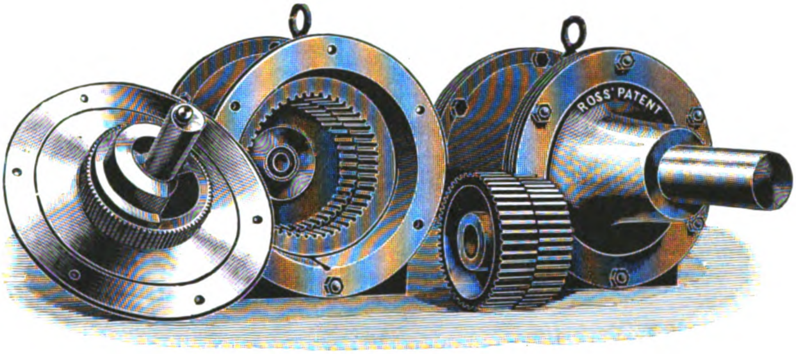


FIG. 1.

As the pinions are usually only a little smaller in diameter than the internal wheels with which they gear, there are, therefore, a large number of teeth always in mesh at one time. This gives great strength to the arrangement, and ensures smooth and silent running. The illustration Fig. 1 shows the outside and inside view of two gears, with the pinions coupled together, lying separate. These are carried on the crank pin, which is provided with a back balance, so that all is in equilibrium. The casing is partly filled with oil, ensuring all the working parts of the gear being thoroughly lubricated. Fig. 2 shows the gear coupled to a motor for reducing the speed of the driving pulley, and Fig. 3 shows an arrangement for driving shop shafting through the gear at a reduced speed. Any ratio of reduction may be secured by the principle of this gear, and some have already been supplied which transmitted the power at a speed ratio of over 6000 to 1. In Fig. 4 is shown one type of the "Ross" patent electric winch,

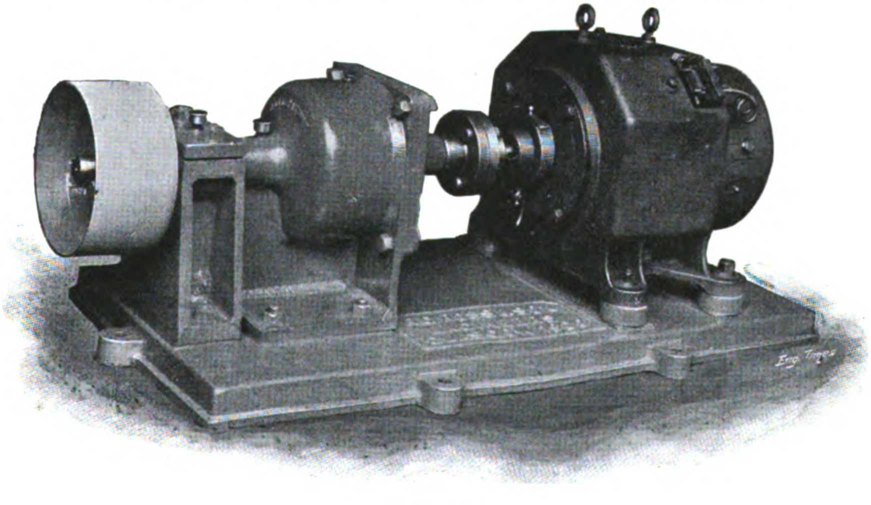


FIG. 2.

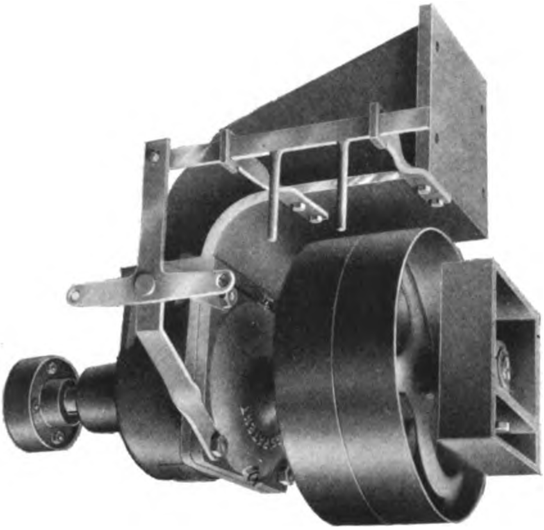


Fig. 3.

large numbers of which have been supplied during the past ten years; they are said to have proved to be most durable and reliable, one firm alone having twenty in constant use. In this winch the reduction is all made in the patent gear box, with the exception of the barrel wheel and pinion, which are fitted with a wheel brake and pawl clutch. When desired the brake and clutch may be combined in the gear box.

Many other modifications are made for a great variety of purposes, such as change-speed gears for motor vehicles, &c., where the different speeds, ahead or reverse, are obtained without the teeth of any of the wheels requiring to slide into other wheels, with the result that there is no danger of breakage or shock when changing speeds, and changes are made instantaneously, positively and silently.

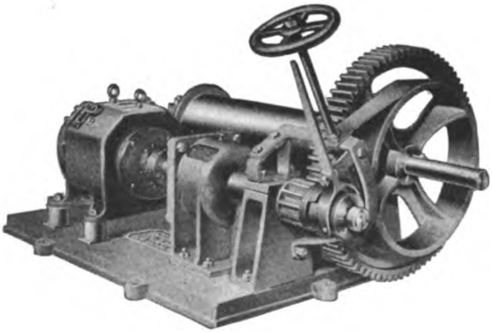


Fig. 4.

❧

A New Electric Winding System for Mines.

Ever since the introduction of electric winding engines the competition between electricity and steam for this service has been severe, and while the electric engine has an undoubted superiority so far as handiness of working and economy in steam consumption of the prime mover are concerned, the initial outlay required by the expensive flywheel converters is so high as to discount to a large extent the corresponding advantages.

A new system of electric drive has, however, been evolved by Messrs. Brown, Boveri, & Co., and the results achieved indicate a distinct advance in favour of the electric system. A plant of this type is installed at the Heinitz mine in Switzerland.

The principle of the arrangement consists in doing away with the flywheel converter of the Ilgner system, and making the boilers act as the accumulator of energy. The plant consists of the necessary boilers supplying steam to a turbine driving a three-phase generator for general power purposes, and on the same shaft a continuous-current dynamo supplying the winding engine motor, which is arranged on the Ward-Leonard system of control. To meet the heavy loads required by the winding gear, the turbine is fitted with an automatic overload valve. This valve is not brought into action by a change of speed—that is, by means of a centrifugal governor—but the speed of the plant is kept practically constant. The overload valve is kept closed by the steam pressure due to the difference in pressure between the boiler and engine sides of the main steam valve on the turbine. So long as the turbine is not fully loaded there will be a certain amount of throttling at the main valve, but as soon as the valve is fully open, *i.e.*, at full load, the throttling disappears and the overload valve opens, admitting high-pressure steam through a bypass to an intermediate stage of the turbine, thus making the latter capable of taking heavy overloads. An advantage of this arrangement is that if the steam pressure is low the overload valve comes into action so much sooner. The speed regulation of the turbine is excellent; with the normal steady load on the three-phase generator, when the winding engine load was changed straight from the maximum positive load to the maximum negative load, the turbine revolutions varied less than two per cent. Unsuccessful attempts were made to vary the load on the winding plant so as to throw the three-phase machines out of step with the one it was running in parallel with. An abnormal load such as the jamming of the cage would bring out the circuit-breaker and at the same time apply the emergency brakes to the winding engine.

The depth of the shaft is 840 yards, the useful weight raised about seven tons, the speed of the rope 33ft. per second, the duty 230 tons per hour, and the diameter of the drum 26ft. 3in.

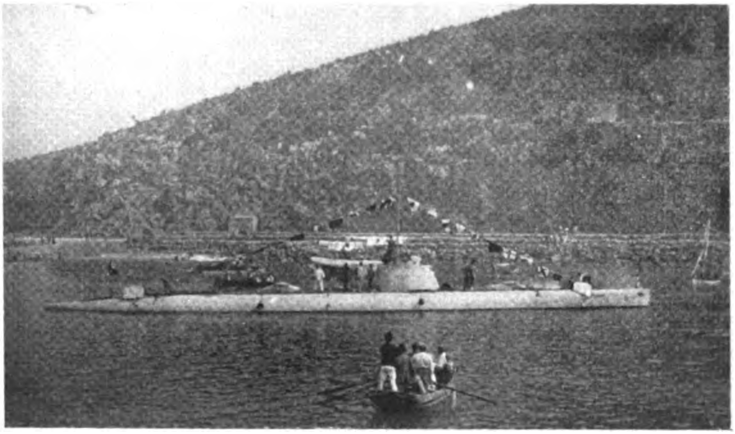
Owing to the slow speed of the winding motor (only 24r.p.m.), it is one of the largest of its kind, the armature being about 18ft. in diameter.

The advantages of this system over the Ilgner are: smaller number of machines and apparatus; avoidance of the expensive flywheel converter with its complex slip arrangement and constant energy consumption; hence higher efficiency of the whole plant, less initial outlay, less maintenance costs, and less attendance required. In addition, the plant can be got away at short notice and is always ready.

An Electric Submarine.

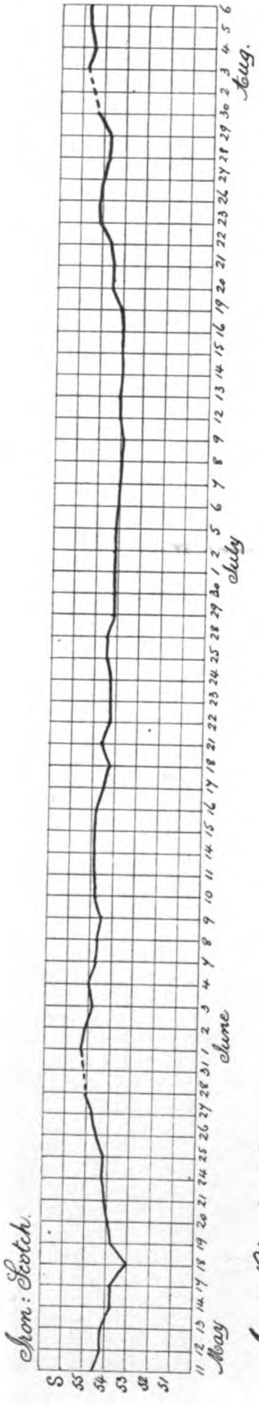
THE submarine boat *Dykkeren*, launched on the 18th of last month at the shipyard of the Fiat-San Giorgio at Muggiano, was built to the order of the Danish Marine Ministry and is the first of her kind which that nation possesses. Her chief characteristics are: length 34.65 metres; breadth 3.35 metres: draught 2.20 metres; displacement when on surface 103 tons; displacement when completely submerged 128 tons; maximum speed on surface 11 knots; maximum speed when submerged 7½ knots. The submarine is propelled by electric motors supplied by a powerful battery of electric accumulators, which give her a capacity of 75 miles at cruising speed.

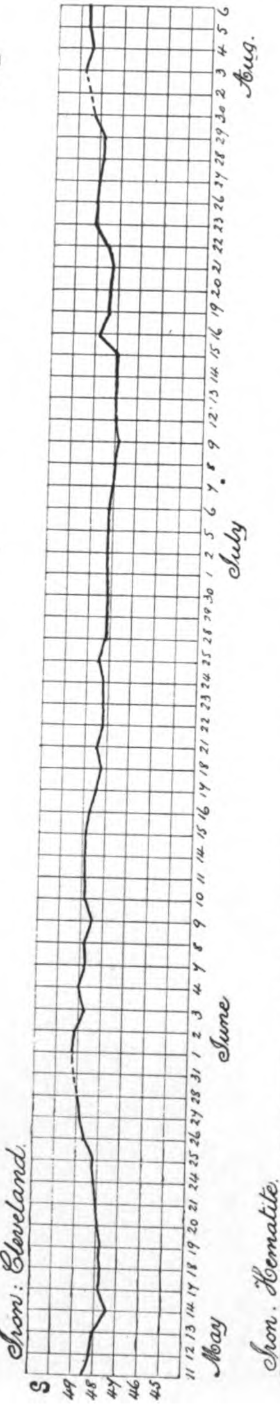
The armaments of the *Dykkeren* consist of two torpedo-tubes and two torpedoes of 5.20 metres length. The Fiat-San Giorgio have specialised in the construction of submarines, one of their latest boats of this type being the Swedish submarine *Hvalen*, which was launched last February.

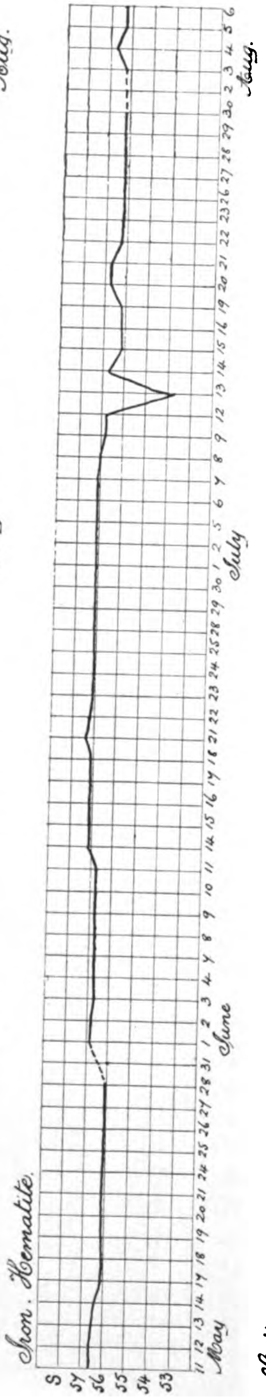


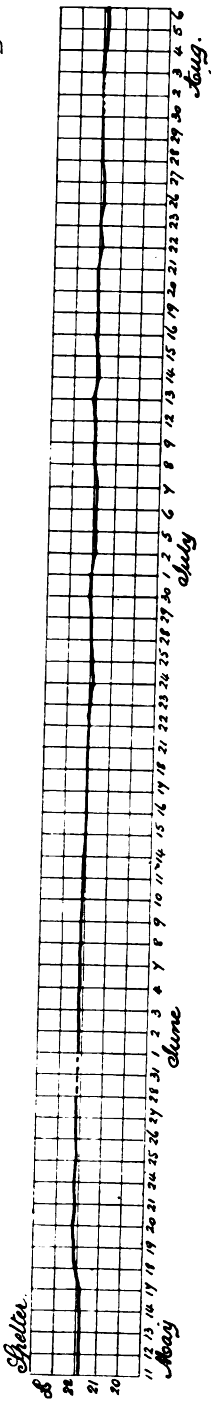
THE DANISH SUBMARINE "DYKKEREN."

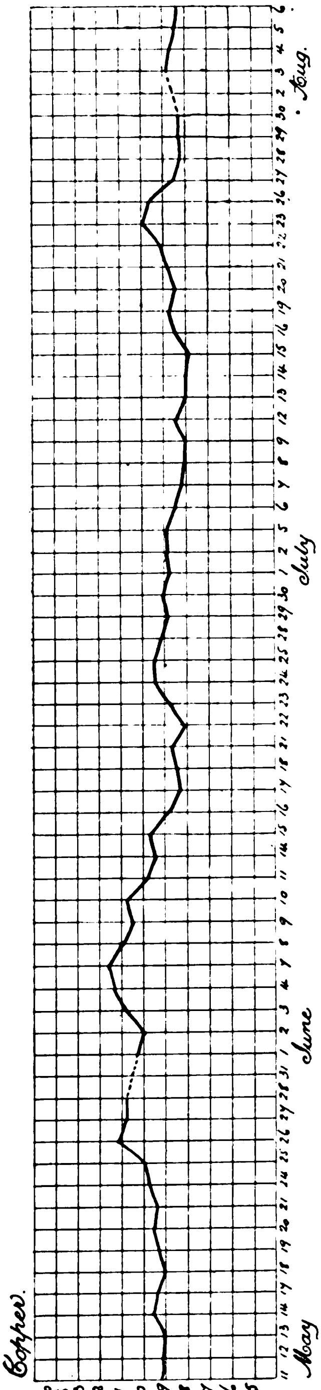
Home Market Metal Prices for the Past Three Months.







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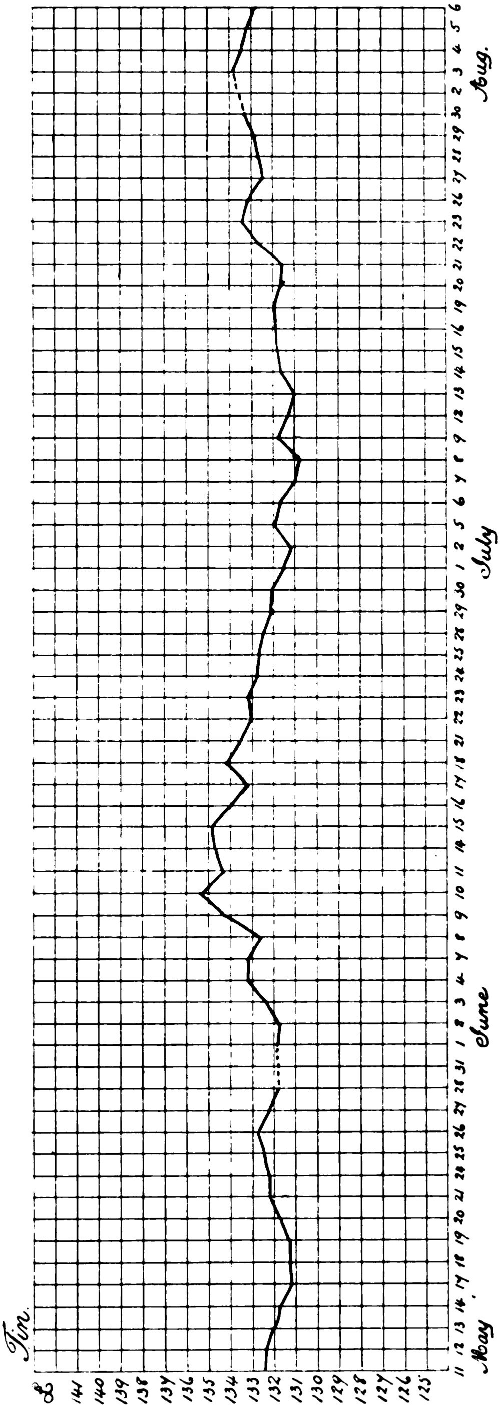
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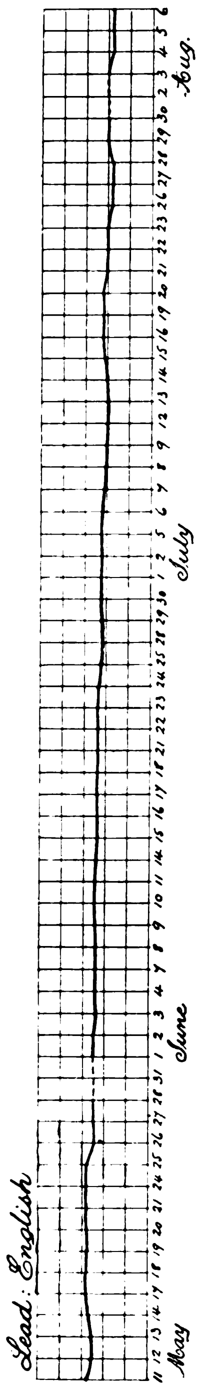
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Dust Prevention in Collieries.

AN ingenious appliance for the automatic spraying of coal is in use in a German mine. Experience, often attended with tragedy, has shown that in dusty mines the use of the spray is sometimes neglected. At the Karolinenglück Mine the automatic apparatus consists of a large rose suspended over the truck rails and connected to the water supply. A long treadle lever working alongside one of the rails is so arranged that it is depressed by the wheels of a passing truck and opens a cock admitting water to the rose. Thus each truck of coal as it passes from the working face is drenched with the water spray. The treadle is of such a length that trains of several trucks are sprayed as readily as one, the treadle only rising and cutting off the water after the last truck of a train has passed over it. The short time this apparatus has been in use has served to show its practicability and also its limitations—it is not "fool-proof," and the desirable improvement is one which will prevent the interference of the miners with its automatic operation. Already there has been trouble, the apparatus being thrown out of action by the wilful wedging up of the treadle lever.

❧

Automatic Regulation of Temperature of Electric Furnaces.

M. KOLOWRAT recently described at a meeting of the Physical Society of France an ingenious contrivance for maintaining a constant temperature in the electric furnace. A pyrometer consisting of a platinum-platinum-rhodium thermo-couple is placed in the furnace, and is connected in the usual way to a galvanometer. On the pointer of the instrument is mounted a small mirror measuring 4cm. by 5cm., and this mirror is so arranged that, when the temperature of the furnace increases and consequently the pointer moves over the scale of the galvanometer, at a predetermined point the rays of a Nernst lamp fall on the mirror and are reflected back on to a sensitive thermopile consisting of twenty copper-constantan junctions. The current generated in this latter thermopile is sufficient to actuate a system of relays, by means of which resistances are introduced into the main circuit of the furnace. As soon as the resistance is switched in, the temperature of the furnace falls, and the pointer of the galvanometer with the mirror moves back to the zero point. The rays of the Nernst lamp are then no longer reflected on to the thermopile, and, the current in the latter falling to zero, the resistances are shunted out of the main circuit, and the temperature of the furnace commences to rise until the mirror comes into action again. This arrangement forms a very sensitive governor; it is especially sensitive when the apparatus is arranged on the potentiometer principle; that is to say, the e.m.f. generated by the thermo-couple in the furnace is balanced by a counter e.m.f. (from a standard cell with resistance), so that the galvanometer stands at zero when the temperature of the furnace is of the desired degree. Obviously the apparatus is easily adjustable for different temperatures. In a furnace working at 1000deg. Centigrade the apparatus only permitted a variation of from 2 per cent. to 3 per cent. on either side. For all practical purposes that variation is sufficiently accurate, but this sensibility could be improved upon by employing a type of furnace which would respond more readily to an alteration of the current density.

❧

Electric Power in Textile Factories.

A PAPER on this subject, read by Mr. H. W. Wilson at the annual meeting of the Institution of Mechanical Engineers, held in Liverpool last month, gave a very clear comparison between the modern electrically-driven cotton mill and the older style of factory. The author covered the many and diverse points in a complete and concise statement. Such features as arrangement of factory, convenience, simplicity, flexibility, transmission economy, and so on, have been pretty well threshed out in argument many times over, and mill managers and electrical engineers are practically in agreement as to these particular merits of the electric drive. Matters of first cost, motor-powers necessary, and effect on quantity and quality of output are, however, vital questions which are still more or less debatable. Emphasizing the great importance of these features, the author claims superior merits for the electric motor and cites examples in proof. He points out that it has been proved in many cases that electrically-driven spindles in a mill can be run at a higher average speed, on the same counts, than mechanically-driven ones, with a corresponding higher production, and this can only be accounted for by the fact that the electrically-driven spindles run more steadily. Except in cases where a varying speed is arranged for to suit special conditions, an absolutely constant speed is most desirable. The tension on the yarn being spun is mainly dependent upon the spindle speed. Slight variations in speed above that corresponding to the maximum safe tension break the threads, and unless absolutely constant speed can be relied upon it is necessary to allow a margin of safety and to run at a speed materially below the breaking-point.

In an electrically-driven factory properly laid out the speed of every machine should correspond directly with the speed of the prime mover, and given satisfactory regulation on the engine, every producing machine can be speeded up to its safe maximum and kept there. With even the best rope transmissions it has been found in a number of cases in Lancashire mills that the speed of the machines closest to the driving point is steadier and higher than that of the machines furthest away. In other words, the one machine will give a larger output than the other.

TABLE I.

Machines.	Horse-power.
1 Bale Breaker and Lattice Mixing Arrangement..	3
3 Horizontal Exhaust Openers..	18
10 Single Scutchers	35
84 Carding Engines	84
11 Draw Frames	20
9 Slubbers, total spindles 882	17
16 Intermediates, total spindles 2212	36
40 Rovers, total spindles 6880	100
28 Mules, 1⅛in. gauge, total spindles 36,063 . ..	314
40 Mules, 1⅜in. ,, ,, ,, 42,320	242
Total.. ..	869

TABLE II.

Machines.	H.P.—Approx.	R.P.M.	Load.
Hopper Bale-Breaker . .	3	300	Steady if feed is regular.
Hopper Feeder	1½	600 850-1000	,,
Exhaust Opener	6–8	950–1400	,,
Single Scutcher	3½–5½	950–1400	Steady
Carding Engine	1	140–190	,,
Drawing Frame	0.15 per delivery	180–300	8–27.5% loss of time due to stoppages; load steady during run.
Slubbing Frame	45 sps. per h.p.	200–450	39-22% ,,
Intermediate Frame . .	55 sps. per h.p.	360–490	18–8% ,,
Roving Frame .	65 sps. per h.p.	360–480	17-5% ,,
Ring Frame . .	70 sps. per h.p.	600–1000	5-10% ,,
Mules	100 sps. per h.p.	—	4-7½% loss; load very variable.
Doubling Frame	40-70 sps. per h.p.	600–1000	5-10% loss; steady during run.
Winding . . .	300 sps.	140–180	Steady.
Beaming . . .	6 per h.p.	40	,,
Sizing Machine	1½-3	210–300	,,

In one fairly well-known case in Lancashire, with two mills under the same management and of about the same size and working under the same general conditions, the results obtained from the electrically-driven factory have been distinctly superior to those from the mechanically-driven one. To such a marked extent was the improvement in quality of yarn noticeable, that the output of the electrically-driven mill fetched a distinctly better price than that from the

TABLE III.

MACHINES.	SIZE OF MOTORS.
Bale Breakers, Exhaust Openers, Lattice Mixers, Scutchers	45h.p. 575r.p.m. directly connected to line shaft.
20 Carding Engines, 3 Draw Frames, 3 Slubbers, and 6 Intermediate	55h.p. 575r.p.m. driving counter-shaft with ropes.
3 Pairs of Mules and 14 Rovers	100h.p. 580r.p.m.
6 Pairs of Mules	130h.p. 530r.p.m.
4 Pairs of Mules and several Ring Frames	100h.p. 580r.p.m
120 Looms	50 h.p. 580r.p.m.
153 Looms	65h.p. 580r.p.m.

TABLE IV.

MACHINES.	DRIVEN BY
2 Waste Pickers	1 Motor 12h.p.
1 Roving Waste-Opener	
2 Hopper Bale-Breakers with Lattice Mixers	
4 Hopper Feeders	2 Motors 40h.p. each.
4 Horizontal Openers with Double Scutchers	
12 Single Scutchers	
84 Cards, 45-inch cylinder	2 Motors 65 and 50h.p.
3 Drawing Frames, each 6 heads of 7 deliveries each.	
8 Slubbing Frames, 100 spindles	2 Motors 90 and 75h.p.
19 Intermediates, each 146 spindles	
45 Rovers, each 184 spindles	
63 Ring Frames, 2¼in. gauge, 6in. lift. Total spindles 34,864	Several motors aggregating 850h.p.; in 200h.p. and 150h.p. units.
32 Mules, 1¼in. gauge. Total spindles 41,216	
3 Winders, 2000 spindles	15h.p. Approximate total=1250h.p.
10 Beaming Engines	

other factory, the increase being stated at about 2½ per cent. In addition to this increase in quality of the product, it may be taken that there is the further advantage of an increase of at least five per cent. in the quantity produced.

Considering the question of horse-powers required, the author presented some figures from mills actually working near Manchester. In Table I. is given a list of the machines installed in a small mule-spinning mill, with statement of the horse-power required by the various machines, calculated on the usual basis.

Table II. gives a more accurate statement of the power required per machine, or the *average* number of spindles per horse-power, the speed of running of the machine, and the nature of the load provided by the machine, including also an estimate of the time the machine is standing idle for doffing, shown as a percentage of the total running time.

In Tables III. and IV. are given the sizes of motors actually installed in two mills in Lancashire where group-driving is employed, and it may be said that in nearly all cases these motors are direct-coupled to high-speed line shafts. It must be remembered that in all these cases the *average* number of spindles per h.p. is stated, and this may vary considerably with the speed of the spindles and class of counts spun.

In the case of ring frames the number of spindles per h.p. may vary between 140 at 6000r.p.m., and 80 at 9000r.p.m., so that great care has to be exercised in considering the question of the size of motors required.

* * *

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ACCELERATION IN COLLIERY WINDING.

THE importance of rapid acceleration and deceleration in colliery winding is rapidly increasing owing to the deepening of shafts, the more intensive working of pits, and, most recently, the shortening of shifts. Where electric winding is employed, the high capital cost of the equipment needs a high frequency of winding in conjunction with the high efficiency of the system to ensure an adequate return on the outlay. The effect of the acceleration employed (and the consequent frequency of winding possible) on the energy consumption of the prime mover per wind is not great, in the case of electric operation, so long as this frequency is fairly high. Thus, for thirty winds per hour, Becker has found the energy consumption per wind to be only slightly greater than for sixty winds per hour, but below twenty winds per hour the efficiency rapidly falls off. There is considerable friction loss by windage on all high-speed flywheels, frequently amounting to 5 per cent. to 10 per cent. of the total energy supplied to the storage set; an analogous and equally serious loss in steam-driven sets is the condensation in the cylinder jackets (as much as five tons of coal being needed to keep the jackets of the winding engine hot for twenty-four hours in a certain Welsh colliery). To keep down the relative importance of such losses, as well as to secure a high plant load factor, winding should clearly be as frequent as possible. The necessity for high accelerations, positive and negative, is thus justified.

Among the factors influencing the maximum permissible acceleration in any winding equipment are:—(1) The average and maximum loads to be dealt with. (2) The inertia of all the moving parts, and the friction to be overcome. (3) The strength of the rope used. (4) The weight of the flywheel and its speed range. (5) The horse-power of the motor used. (6) The over-all speed of winding desired, and the maximum speed during the cycle. (7) The extent to which the demand on the mains may fluctuate.

Winding Acceleration.

To ensure a steady demand on the supply mains it is desirable that the excess energy taken during acceleration, over that required during the constant speed period of winding, be supplied wholly by the flywheel, leaving the motor load, and hence the load on the mains, as nearly constant as possible. This requires that during the retarding and "decking" periods the motor, running at its normal horse-power, shall store sufficient energy in the flywheel to supply the subsequent acceleration peak in the load curve. The motor rating must, therefore, provide for continuous running at full load.

It has been shown that the *desirable* accelerations and retardations are the highest obtainable with safety, with reasonable demands on the supply mains, and with reasonable variations in the flywheel speed. The minimum flywheel speed should not be less than the maximum by more than 10 per cent. to 15 per cent. of the latter. The safety considerations referred to mainly concern the rope stresses on starting, although, if very high winding speeds be employed for raising coal, lower speeds must be provided for the haulage of men. In England a moderate winding speed, which is the same for men and coal, is usually employed.

The general method of approaching all problems concerning winding acceleration, whether with the object of determining the size of flywheel required to allow of a given acceleration, or of calculating the permissible acceleration with a given flywheel, is set out below.

Suppose that a nett load of W tons has to be raised from a depth of D feet in T seconds (including decking) then the useful work done is

$$= \frac{2240 \times W \times D}{T} \text{ ft. lbs. per second,} \qquad (1)$$

and, hence, if the retarding and decking occupies t seconds, the flywheel must store

$$\frac{2240\ W\ D}{T} \times t \text{ ft. lbs.} \qquad (2)$$

in consequence of a rise in speed from n to N r.p.m. — the minimum and maximum speeds respectively.

Assuming a simple disc flywheel of diameter d feet and weight w lbs., and allowing a peripheral velocity of 95m. per second (17,000ft. per minute),

$$d = \frac{17{,}000}{\pi N} \text{ ft.} \qquad (3)$$

and the energy absorbed or given out by a change of speed from n to N r.p.m., or *vice versa* is

$$= \frac{w}{8g} \cdot d^2 \cdot \frac{\pi^2}{(30)^2} (N^2 - n^2) \text{ ft. lbs.} \qquad (4)$$

whence, by equating (2) and (4), the weight

$$\text{of flywheel} = 0.000802 \times \frac{W D t N^2}{T (N^2 - n^2)} \text{tons,} \qquad (5)$$

and the output of motor required,

$$= 2240 \frac{W\ D}{T} \text{ ft. lbs. per second} =$$

$$4.07 \times \frac{W\ D}{T} \text{ horse power.} \qquad (6)$$

The maximum acceleration (a) desirable is that which produces a rope load $= 2 \times$ dead load, *i.e.*, a is given by

$$W = I \frac{a}{r^2}, \textit{ i.e.}, a = \frac{W r^2}{I} \qquad (7)$$

where I is the total moment of inertia of all the moving parts of the winding system: r the radius of the winding drum.

If the maximum winding velocity be v ft. per second, the accelerating period $= \frac{v}{a}$ seconds, during which time the energy available from the normal output of the motor + the retardation of the flywheel is

$$= 2240 \frac{W\ D}{T} \left(\frac{v}{a} + t\right) \text{ ft. lbs.} \qquad (8)$$

while the rope tension during acceleration is

$$R = W \left(1 + \frac{a}{g}\right) \text{ lbs.} \qquad (9)$$

and the work required to be done during acceleration is

$$= C\theta = \left(Rr + I.\frac{a}{r}\right) \frac{v^2}{2ar} \text{ ft. lbs.} \qquad (10)$$

If now the available energy (equation 8) be greater than or equal to the energy required (equation 10), the maximum permissible acceleration a ft. per sec. can be worked to: otherwise a lower acceleration must be accepted *or* a more powerful motor must be installed, *or* the flywheel must be heavier or given a wider speed range (either of which alternatives will lengthen the duration of the winding cycle). It is here assumed that the demand on the supply mains and the maximum speed of winding remain constant.

The rate of retardation may be considerably greater than the rate of acceleration, a return and not an expenditure of energy being concerned. In most cases the deceleration is from two to three times as rapid as the acceleration. With a maximum winding speed of about 20ft. per sec. the acceleration may be 1ft. to 1½ft. per sec.^{2}, and the deceleration 3ft. to 4ft. per sec.^{2}, while for maximum speeds of 40ft. to 50ft. per sec.—practically the highest yet attempted, and only used in the deepest shafts, mainly on the Continent—the acceleration and deceleration are from 1.5 times to twice as great. The distribution of the total time occupied by a winding cycle over its various operations in four typical instances is shown in Table I., whence it appears that acceleration usually occupies from 25 per cent. to 30 per cent. of the actual winding period, while deceleration only occupies about 10 per cent. to 15 per cent. thereof (case 1 being accepted, in the latter statement, as being rather unusual). This ratio, 2.5 to 3 : 1, agrees with the remarks already made concerning the relative magnitudes of the positive and negative accelerations.

TABLE I.

Case Number.	Duration of various Operations of Winding Cycle.									
	Accelerating.		Full Speed Running.		Decelerating.		Decking.		Actual Winding *A*. Seconds.	Complete Winding Cycle. Seconds.
	Seconds.	Per cent. of *A*.	Seconds.	Per cent. of *A*.	Seconds.	Per cent. of *A*.	Seconds.	Per cent. of *A*.		
1	16	26.3	27.0	44.3	18	29.5	17.0	27.9	61.0	78
2	12	30.0	23.0	57.5	5	12.5	15.0	37.5	40.0	55
3	19	29.7	40 5	60.9	6.4	9.6	23.3	35.1	66.7	90
4	10	20.0	35.0	70.0	5	10.0	20.0	40.0	50.0	70

Comparison of the Accelerations permissible with Steam and Electric Drives.

The increased stresses produced in the winding rope on starting greatly limit the acceleration permissible with steam drive: the starting torque is very uneven in such cases, and the stresses on the rope are correspondingly accentuated. Only one cylinder of a steam winding engine is operative at the moment of starting, and owing to this and to possible unfavourable positions of the valves and cranks, and in spite of great sacrifice of expansive working of the engines to ensure starting in all positions, the torque is very uneven for a time. The heavy moving parts of the steam winding gear necessary to reduce this unevenness to practicable limits are of little value till they have acquired a fair velocity, since the smoothing effect of their inertia can only then become operative.

The size of rope used is ultimately limited by its weight, particularly in deep shafts, and the space taken up on the winding drum. Tapered ropes offer some advantages in this respect, but, on the whole, are not advisable. As a result of this, and in consequence of the higher factor of safety required with steam driving to allow for the more severe rope strains, the accelerations possible are considerably less than may safely be employed with electric winding motors. In the latter case a rope factor of safety of six may be adopted, whereas with steam drive a safety factor of nine or ten is the least permissible. The ratio of the permissible accelerations in the two cases is, therefore, about 1.5 to 2 : 1.

Not only is the starting torque more uniform when employing electric drive, but also, by the use of flywheel storage systems, it may rise to higher absolute values than are obtainable with the otherwise equivalent steam engine. The use of quite a reasonable flywheel may increase the total energy available during the accelerating period to from two to three times that which would be obtainable from the normal output of the motor alone.

Balancing difficulties are practically eliminated by the use of electric motors, which also avoid the enormous frictional losses of steam engines on starting. The latter losses, according to Behr, may rise to 20 per cent. of the engine output, a magnitude which, apart from the superior accelerating qualities of electric motors, would alone justify the conversion.

BIRKENHEAD CORPORATION TRAMWAYS.

To everyone at all connected with street tramway affairs or interested in the history of their beginning and development, the mention of Birkenhead always recalls the fact that it was in this town in the year 1860 that Mr. George Francis Train, after failing to convince Londoners of that day of the merits of the system of which he had gained some experience in America of running vehicles on grooved rails laid in the streets, was successful in finding a public body with sufficient foresight to allow a trial of what was at that time regarded as a revolutionary idea in road transport. A length of about one and a half miles of track was laid, and formed the beginning of a system of horse-drawn trams which served the town more or less satisfactorily until the year 1900, when, not to be outdone in the provision of a public convenience of which their predecessors had been the pioneers, the Corporation were moved to purchase the old horse-car system, and immediately commenced the reconstruction and conversion of the line to electric traction. The result of their efforts is a service of electric tramways well laid out, well managed, and up to date in every respect. In fact, it is a proud boast of local enthusiasts that the lines are so laid that there is no portion of the borough which is more than a quarter of a mile distant from a tram line.

Birkenhead has been aptly described as Liverpool's bedroom, and it is owing to the ebb and flow of the traffic morning and evening, and in a lesser degree throughout the day, to and from Liverpool by way of the Corporation ferries, and the Mersey Railway Company's electric railway tunnel under the River Mersey, that the whole of the lines converge at the Woodside Ferry.

The first route, viz., the New Ferry route, which runs from Birkenhead to New Ferry and within a short distance of the village and soap works of Port Sunlight, was opened on February 4, 1901, other routes opening in August, September, and December of the same year.

The system now comprises 13.68 route miles, or, measured as single track, 24.14 miles. The permanent way is of the usual 4ft. 8½in. gauge. Steel girder rails weighing 100lb. per yard have been used in 60ft. lengths. The rails are 7in. in depth, with a 7in. flange and 2in. tread, and the groove is 1in. wide by 1⅛in. deep. The rails are tied with 2in. by ½in. steel tie-bars fixed 10ft. apart. The rail joints are formed with steel fish plates 2ft. long, weighing 54lb. per pair, secured with 1in. bolts. The joints are further strengthened with anchor joint plates, and two intermediate holding-down plates have been fixed to each rail.

The lines are bonded with two 29in. Chicago crown solid bonds to each joint, 0000 B & S gauge. The rails are also cross-bonded at intervals of 40 yards with 0.406in. wire.

The track has been constructed with easy curves, the quickest having a radius of 40ft. Gradients are not numerous, but at least two are rather severe, one in Pearson Road being a gradient of 1 in 13½ over a distance of 360 yards, besides which on this gradient there is a sharp S curve, rendering it a particularly difficult piece of line to negotiate. It, however, testifies to the careful management and training of the staff that not a single accident has happened on this gradient in over eight years' working.

The rails and paving of the tramway track have been laid upon a foundation of Portland cement concrete, 6in. thick, the paving being mainly of wood blocks with a small portion of granite setts.

The rails were supplied by Messrs. Bolckow, Vaughan, & Co., Ltd.; points and crossings by Messrs. Hadfield's Steel Foundry Company, Messrs. Askham Brothers & Wilson, and the Lorain Steel Company.

The overhead electrical equipment has received special attention, and is of very substantial construction, the trolley wire being supported approximately 21ft. above the track by bowstring suspension from poles placed in the centre of the roadway where the width of the streets admits of this method of construction, and from bracket arms on side poles in the narrower thoroughfares, with span wires in a few instances. The trolley wire is double throughout and is of 0.4in. hard-drawn copper wire, and the poles are 31ft. in length and composed of three sections. Current is supplied to the trolley wires by five feeder mains supplied by Messrs. Callender's Cable and Construction Company, and the British Insulated and Helsby Cables Company, Ltd., partly of paper-insulated and lead-covered cables, and partly of cables insulated with vulcanised bitumen, both classes of mains being laid in troughing, filled up solid with bitumen or pitch compound. Section boxes are provided at half-mile intervals over the whole system, and telephones directly connecting with the generating stations and car depôts are provided at the section boxes for which all tramway inspectors, drivers, conductors and officials have keys.

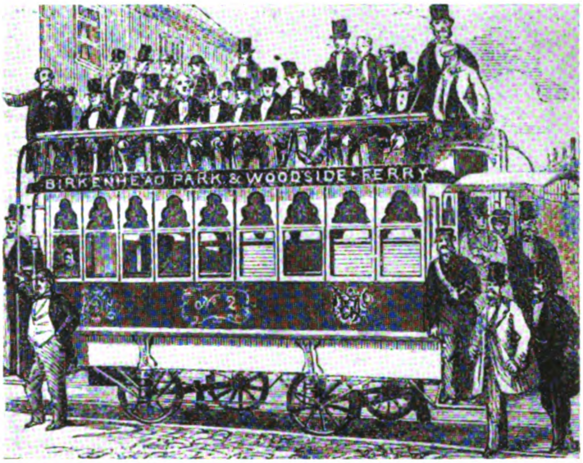


FIG. 1. FIRST CAR OF THE FIRST BRITISH TRAMWAY.

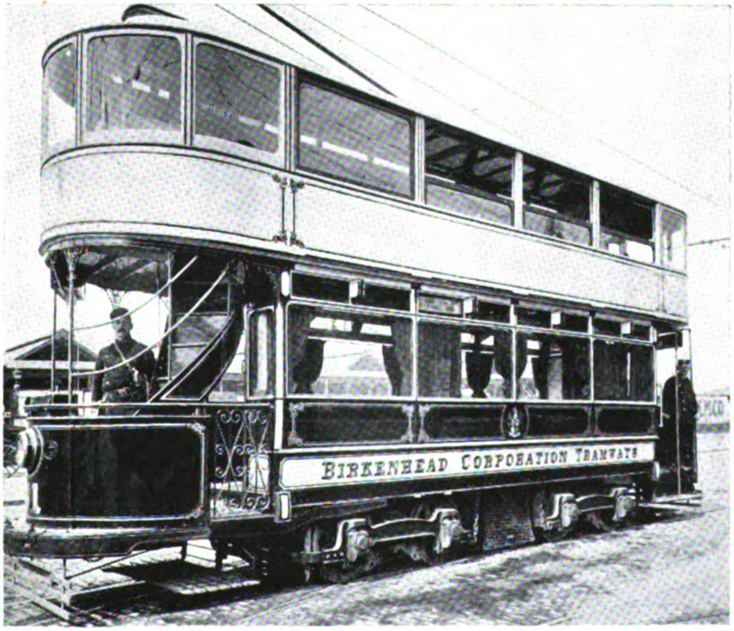


FIG. 2. DOUBLE-DECK CAR WITH TOP COVER FITTED

Two generating stations were provided for the tramways, one situated at Craven Street, practically in the centre of the system, and a smaller station in New Chester Road. The latter station was originally intended to supply current for the New Ferry section, on which route it is situated, but owing to the expense entailed in running two separate stations, and the generating plant at the larger station at Craven Street being capable of supplying the whole system, the smaller station has been shut down as a generating station and is now run only as a distributing sub-station for both the tramways and electric lighting departments. The central generating station contains a suite of offices and battery room fronting on to Craven Street with storage rooms, workshops, boiler house, and engine room in the rear.

The battery room contains a battery of 240 E.P.S. cells working in series with an automatically reversible compound wound booster capable of giving 400amp. continuously for one hour, and connected in parallel with the generators. The station is equipped with five Lancashire boilers, each 30ft. long by 8ft. diameter, working at a pressure of 160lb. per square inch, fitted with motor-driven mechanical stokers and supplied with hot feed water by means of a duplicate set of Green's economisers; four Willans high-speed vertical-compound condensing engines, having an aggregate output of 1700i.h.p., direct-coupled to four compound-wound continuous-current multipolar generators having a total output of 1275kw. at a generating pressure of 550 volts, giving a pressure at the motors of the cars of 500 volts and a maximum load on the feeders of 1000kw. The switchboard, placed on a gallery at one end of the engine room, consists of eleven panels, including three generators, one battery, one main, one Board of Trade and five feeder panels. They are provided with Crompton switches, and general instruments, B.T.H. magnetic blow-out circuit-breakers, and Weston recording instruments. The output of this station for traction purposes is approximately 2½ million units per annum.

There are two car sheds in connection with the tramways, the smaller one at the terminus of the New Ferry route capable of accommodating fourteen cars, and the main depôt at Laird Street, at the opposite end of the system, this depôt having accommodation for the housing, cleaning, and repairing of sixty cars, and there is sufficient surplus ground to provide for considerable extension of the depôt should it be found necessary. This shed contains a well-equipped fitting shop, store room, joiners' shop, sand store, &c., and attached to the main building there are mess-rooms for the night and day shifts, armature winders' room, foremen's office, salt store, &c. The fitting and joiners' shops are admirably equipped with machines necessary for the complete repairing and overhauling of all the rolling stock. The machines included in the shops are as follows:—

Hydraulic wheel press, surfacing and screw cutting lathe, wheel turning lathe, radial drilling machine and small drills, shaping machine, grindstone, power hammer, general wood worker, band saw, power hack saw, mortising machine, overhead cranes running the full length of the repair shops, car lifting appliances, &c. The shops are driven by a 15h.p. motor. Novel use has been made at very small cost of an engine and boiler previously used by the old horse-car company for driving a hay chopper. This set has been converted into an air compressor, and fulfils the threefold duties of mechanical blower for smith's fire, supplying compressed air for cleaning the motors and armatures, and cleaning the seat rugs and cars by the vacuum process. At the end of the tracks inside the shed there is an electric pit traverser working in a pit 38ft. by 23ft. for the purpose of moving cars into the repair and fitting shops. With the exception of one side, which is constructed with machine-made grey brick with red pressed brick and terra cotta dressings, the car shed consists of a steel trussed, boarded and slated roof in four spans and supported upon steel stanchions.

The Corporation have erected in their own workshops top deck covers for sixteen

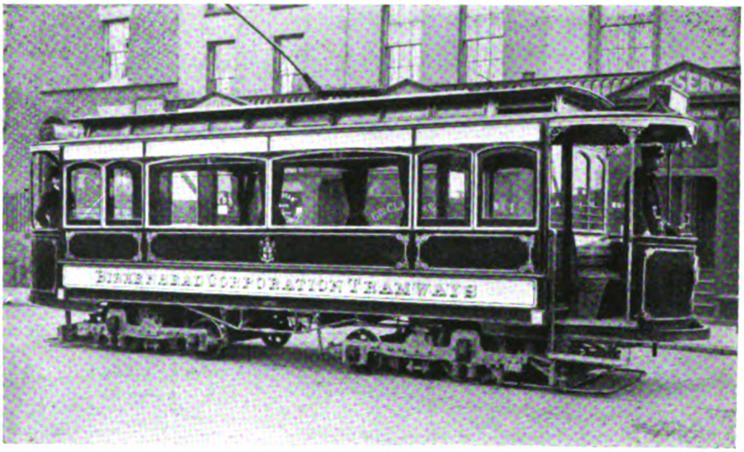


Fig. 3. Single-deck Double-bogie Car.

double bogie cars, illustration of which is shown, and one single-truck car. They have also built throughout trucks for fifteen double-bogie cars, and carried out from the commencement the whole of the armature winding, repainting, and repairs required in connection with the running of the system. The rolling stock consists of:—

31 single-truck double-bogie cars mounted on Peckham cantilever extension trucks and with B.T.H. GE52 equipments.

15 double-truck double-deck cars, mounted on double-bogie equal-wheel trucks, built throughout in the Corporation's own workshops, with Witting Brothers' equipments.

13 bogie-truck double-deck cars, mounted on Mountain & Gibson (L.C.C. type) maximum traction trucks, with B.T.H. GE52 equipments.

1 combined snow plough and break-down car, equipped with 2 GE58 motors, constructed throughout in the Corporation's workshops.

1 water sprinkler of 2000 gallons' capacity, arranged to flush both rails, and also to sprinkle the roadway for a distance of three feet at each side of track, spread by gravity, equipped with 2 GE52 motors, constructed throughout in Corporation's workshops.

The whole of the car bodies were built by Messrs. G. F. Milnes & Co., Ltd., of Birkenhead, before that firm removed their works to Hadley, Shropshire.

The thirteen bogie truck cars were originally single-deck cars built specially for the New Ferry route, on which there is a low railway bridge which prevented the ordinary form of double-deck cars passing under, and for some years carried traffic more or less satisfactorily, but recently, owing to the very considerable amount of traffic to and from the great works of Messrs. Lever Brothers at Port Sunlight, of "Sunlight Soap" fame, which has to be catered for during a very limited time morning and evening, the single-deck cars were found to be quite insufficient for the work, even with a service of four minutes' frequency, and the Tramways Committee were faced with the very difficult problem as to how to cope with the increasing traffic. The question of raising or removing the offending bridge would have been a very costly one. The road also had been lowered to the utmost possible limits without rendering it liable to flood at high tides, and consequently there only remained the alternative of increasing the carrying capacity of the cars.

The clearance between the rail of the bridge is only 14ft. 8$\frac{3}{4}$in., whilst the overall measurement of the ordinary double-deck car in use on the Birkenhead system is 17ft. 3in.

The difficulty has been solved by converting the single-deck cars into double-deck cars, which in many respects are somewhat novel, and we believe are of the lowest overall measurements of any double-deck cars running in this country. The roofs of the saloon in the single-deck cars have been entirely reconstructed, the sides having been lowered, and the space taken by the monitor roof of the lower saloon being placed under the seats in the upper saloon, which are fixed longitudinally along the centre of the car, the passengers sitting back to back, the "dip" to the sides of the roof to the bottom saloon being taken advantage of to permit of headroom being given along the sides of the upper saloon.

The passengers when boarding the top saloon enter direct into the covered portion, and are protected from coming in contact with the bridge and overhead equipment, it being impossible for anyone to accidentally touch either. The overall height of the car to top of trolley base when fitted with new tyres and springs is 14ft. 6in., as against the clearance between the rail and bridge of 14ft. 8¾in. The height of the lower saloon in the centre is 6ft. 4in., and at the sides 5ft. 5½in., whilst the height of the upper saloon in the walking space along the sides is 5ft. 5in. The effect of this alteration has been to increase the seating capacity of the cars from 33 to 64 passengers, giving on the thirteen cars a carrying capacity of 832 passengers as against 429 formerly.

The cars are all fitted with what has since become known as the "Birkenhead" staircase, being arranged so that the ingress and exit of passengers from the saloon and the top deck can proceed simultaneously.

Spacious and well-appointed offices are provided, being situated in front of the main depôt, and containing manager's private office, general office, ticket office, correspondent's office, timekeeper's and inspector's offices, &c.

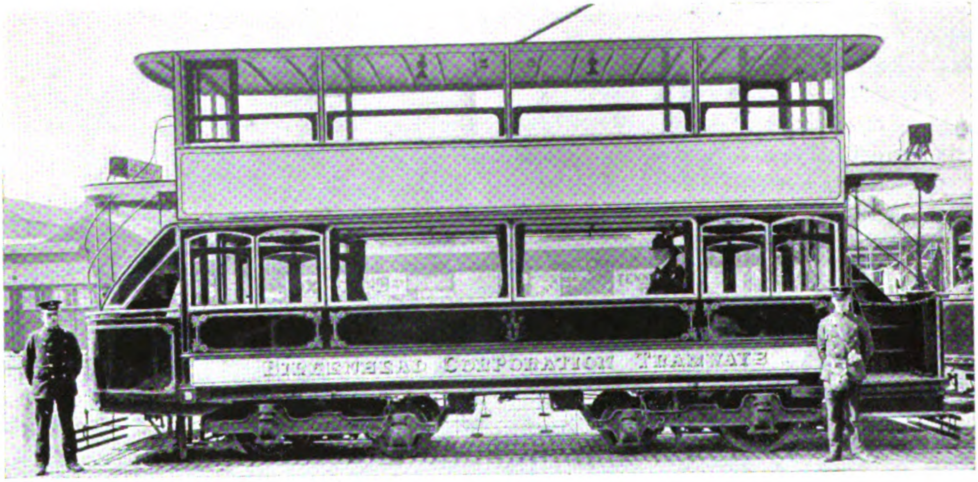


Fig. 4. Single-deck Car converted to Double-deck Covered Car.

The maximum speed allowed by the Board of Trade is 14 miles per hour.

During the eight and a half years the system has been in operation the results financially have been very satisfactory, especially considering the fact that the town possesses little in the way of local industry and has to depend to a very large extent on the morning and evening traffic to and from its larger neighbour—Liverpool.

From the last annual report made by the Borough electrical engineer and tramways manager—Mr. W. Wyld, M.I.M.E., M.I.E.E.—for the year ending March 31 last, we

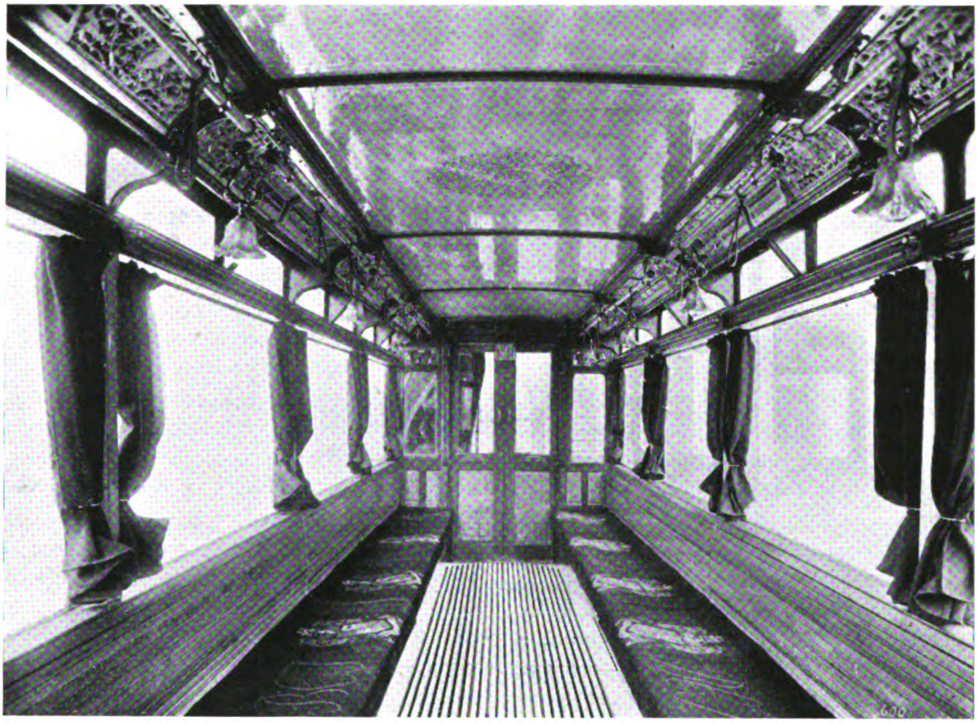


FIG. 5. INTERIOR OF BIRKENHEAD BOGIE CAR.

notice that a total of 12,124,297 passengers have been carried, 1,278,015 miles have been run, and £55,097 taken in receipts. The capital expenditure to date has been £363,428, £71,373 of which has been repaid, besides which £86,655 has been paid in interest on capital, and there is a balance standing to the credit of reserve and renewals fund of £9561.

The fares have been fixed on an exceedingly low scale, especially so in the case of workmen's tickets issued on all cars before 8 a.m., the average fare charged for the latter being only 0.4d. per mile. The working costs compare favourably with those of towns of similar size, the average per mile for the eight years being 6.17d. Considering the appearance of the rolling stock, machinery, and the system generally, it is the evident aim of the Tramways Committee to provide generously in the way of tramway accommodation and to maintain the works in a first-class condition rather than show low costs at the expense of efficiency; in view of this the figure obtained is extremely satisfactory.

ARTIFICIAL LOADS FOR LARGE GENERATORS.

The rapid increase in the output of electric generators during the last few years has led to serious difficulties in the way of designing means of dissipating the energy from such machines during trial runs. The irregular nature of the service, both as regards frequency of occurrence and the amount of available energy, prevents any useful application of the output to driving works' motors, &c., except in rare fortunate cases.

The problem therefore resolves in general into the provision of a suitable idle load, the design of which is of considerable difficulty owing to the magnitude of the amount of energy to be dissipated. The following notes may, therefore, be of general interest and value, as they first deal with the design of metal resistances to dissipate 700kw. at 2200 volts, and then, after setting forth the objections to such a form of load, state the alternatives available.

700kw. to be dissipated at 2200 volts three-phase involves a current per phase of 106amp., which, to expend 233kw. per phase, must flow through 20.7 ohms. The problem is, therefore, to design an iron resistance of 20.7 ohms to carry 106amp. Allowing a current density of 2500amp. per square inch, the area required = 0.0425 square inches, and the iron would then rise to 250deg. to 300deg. F. on steady running in air with average ventilation. Assuming, therefore, the specific resistance = 0.00000878 ohm per inch, the length of wire required = 8400ft., and the section might be 0.26in. × 0.26in., or say 1in. × 0.0425in., according to which proves the more convenient (probably the latter), the weight of iron required would be about 15,200lb., *i.e.*, about 7 tons per phase. The impracticability of this design is obvious. If, however, the iron strip be immersed in water, it can be run at 10 to 20 times the above current density, and the weight of iron required is, therefore, reduced to 1520lb. and 760lb. per phase respectively, the areas and lengths being as in Table I.

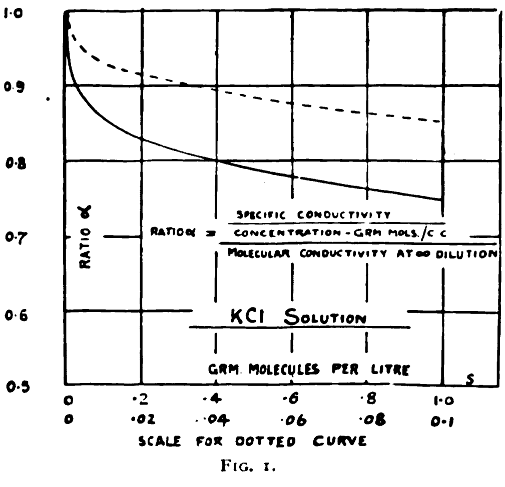


FIG. 1.

TABLE I. DESIGN OF RESISTANCE PER PHASE.

Assumed current density (amp. per sq. inch) - - -	2500	25000	52000
Area resistance strip (sq. in.) -	0.0425	0.00425	0.002125
Length ditto (ft.)	8400	840	420
Dimensions of section (in.) say - - - -	0.26in. square or 1in. × .0425in.	.1535in. × No. 22 S.W.G. or .0735in. dia. wire	.0521in. dia. wire
Weight of iron per phase (lb.)	15200	1520	760

The last two designs are more feasible, but now involve the use of a very fragile strip, and as the rusting and general "wasting" of iron, when exposed to such loading, is very severe, the use of such small strips would not be satisfactory. The rapid drop in the load consequent on the reduction of the area of the iron and the very short life of the strips, coupled with the impossibility of conveniently regulating the load, make such a scheme impracticable in the present case. The difficulty of having to dispose of a very long resistance rod or strip is not overcome even in the third design above. For low-voltage work, where a large enough tank for a water load is not available, such water-cooled iron resistances become very useful. Even at lower voltage, using a stouter strip, say ½in. by 19s.w.g., a life of 8 to 100 hours cannot be much exceeded, assuming current densities of 52,000 and 25,000amp. per square inch respectively. The strips will in most cases have to be carefully zigzagged to enable their accommodation. The lower the voltage, the more suitable metallic resistance becomes, but for voltages such as the present, liquid resistances are the only ones feasible.

It is not advantageous to use too pure water for artificial loads, since beyond a certain limit of specific resistance, the voltage per foot of liquid between the electrodes becomes too great; moreover, slight absolute variations in the amount of impurities present have then a great effect on the conductivity of the solution. This is shown by the curves of Fig. 1, which indicate the relative effect of consecutive equal increments of KCl.

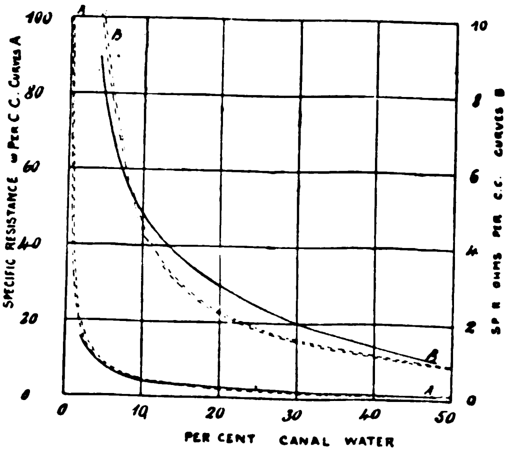


FIG. 2.

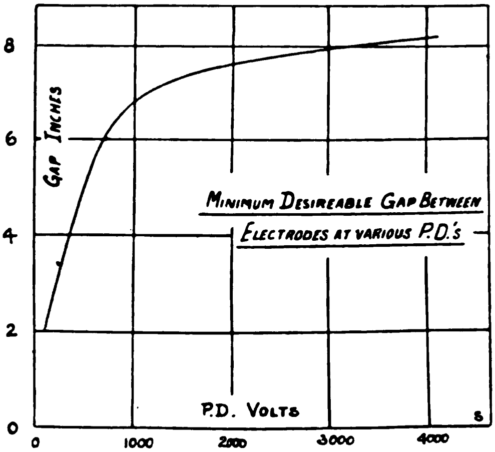


FIG. 3.

These curves are typical of all electrolytes. The specific conductivity of the solution rises as the percentage of KCl increases, but if the specific conductivity $\left(\frac{1}{\text{specific resistance}}\right)$ be divided by the concentration (in grm.-molecules per c.c.), then the molecular conductivity is obtained which decreases as the percentage of KCl increases, showing that the first added molecules of the salt are the most efficient as regards increasing the conductivity of the solution. The limiting value of the molecular conductivity is perfectly definite for every salt, and corresponds to infinite dilution. The efficiency of a given amount of KCl (or other salt) is measured by the ratio a of the molecular conductivity obtaining after the addition of this amount of salt to the solution to the limiting or maximum molecular conductivity (which, in the case of KCl, is $131.2\ \frac{\text{ohms}^{-1}\text{ per c.c.}}{\text{grm.-molecules per c.c.}}$). In Fig. 1 the ratio a is plotted against the concentration of the solution in grm.-molecules per litre. The relative effects of other materials used to form electrolytes are roughly:—Copper sulphate; sodium sulphate; salt solution; potassium hydrate; sulphuric acid = 1 : 2 : 3.3 : 8.9 : 11.1, *i.e.*, the conductance of a 10 per cent. solution (by weight) of H_2SO_4 in pure distilled water is 11.1 times that of a 10 per cent. solution of $CuSO_4$.

Whenever possible no artificial means such as the above should be employed to increase the conductivity of water. Ordinary canal or river water, if not too dirty, fulfils most needs: if it be of too low specific resistance the latter may be raised by the admixture of town water, or, preferably, condensed steam, if available in sufficient quantities. The specific resistance of any such mixtures can be calculated as below with very reasonable approximation to actual results. Consider first the dilution of ideally pure water with a water of specific resistance $= R_1$. The ideal water will have specific resistance $= \infty$ and the addition of P per cent. of the impure water to it would be expected to give a mixture of specific resistance

$$= \frac{R_i \times 100}{P} \qquad (1)$$

If, however, the "pure" water is merely the purest obtainable, and has a specific resistance of R_d, then the "pure" water has n conducting particles per c.c., where $n \propto \frac{1}{R_d}$ and the "impure" water has m conducting particles per c.c. where $m \propto \frac{1}{R_i}$ and one c.c. of a mixture of P per cent. of impure water has $\left(\frac{P(m-n) \times 100n}{100}\right)$ conducting particles, hence the specific resistance of the mixture $\propto \frac{100}{P(m-n) + 100n}$ and

$$= \frac{100}{P\left(\frac{1}{R_i} - \frac{1}{R_d}\right) + \frac{100}{R_d}} \qquad (2)$$

Assuming a canal water of specific resistance 450 ohms per $cm.^3$, and a "pure" water (a) of ∞ specific resistance (b) of specific resistance = 100,000 ohms per $cm.^3$, the two dotted curves, Fig. 2, were obtained by the use of equations (1) and (2) respectively. These equations will be seen to agree closely with the resistance curve obtained experimentally for such a mixture. The curve based on assumption (a) naturally gives the higher specific resistance throughout, but the difference is slight except at very low percentages of impure water. The agreement is throughout closer than would possibly be expected, bearing in mind the results of Fig. 1.

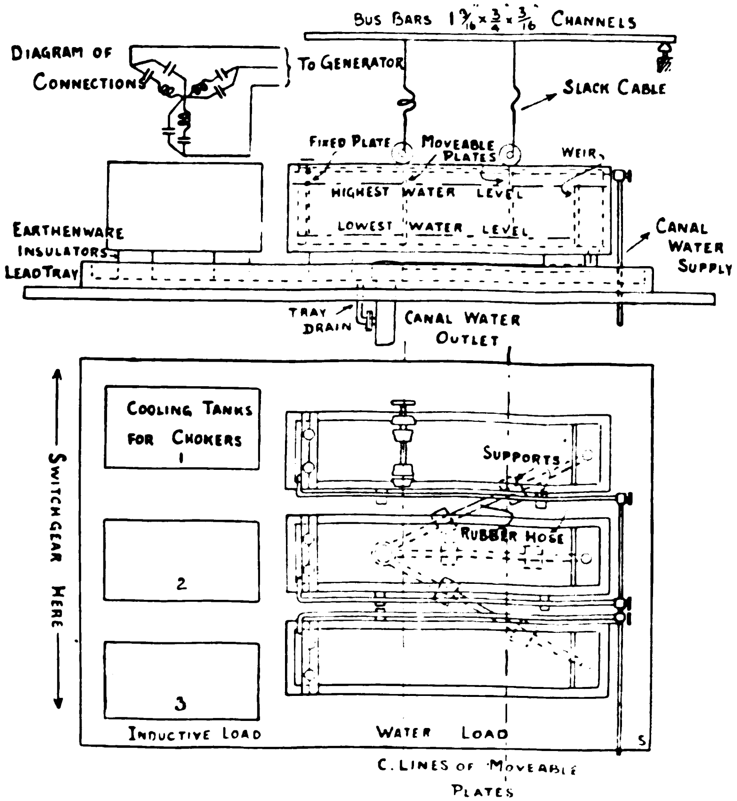
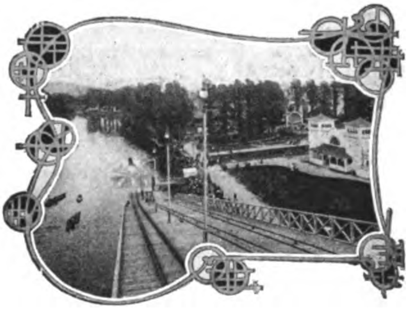


FIG. 4. ARTIFICIAL LOAD SUITABLE FOR 1000KW. AT 1000-6000 VOLTS.

The variation of a water load is effected by moving the electrodes in and out of the water, or to and fro, or by a combination of these motions. The minimum safe distance between electrodes for various test voltages is shown in Fig. 3, the shape of which curve further illustrates the possibility of using proportionally lower factors of safety, the higher the pressure to be safeguarded, within limits, of course. (This is a common feature in all engineering designs, and one of the main reasons for the high cost, weight and size per unit effect of small sizes of all apparatus of whatever description.)

In conclusion, the testing plant recommended by Messrs. Morris & Morcom (Inst. E.E. paper) may be referred to. This is illustrated in Fig. 4, and consists of three long wooden troughs with rubber pipe water inlets and outlets (the latter being over a weir). The tanks are double walled, tarred and caulked: they are mounted on earthenware insulators standing in a leaden tray. The electrodes are of C.I. plate, fed from overhead channel iron busbars through flexible slack cables which allow the electrodes to be moved to and fro. The tanks shown to the left are for cooling the special type of choker used by the above designers. These chokers, by the use of very high flux and current densities, and water cooling, enable a maximum inductive effect to be obtained with a minimum capital outlay and space occupied. The connections, whereby a variable load of variable p.f. is obtained, are shown diagrammatically. The whole apparatus is mounted on a wooden platform and the operator stands on a rubber mat. The position of the switchgear may be as shown, or elsewhere if more convenient. The remaining details of the arrangement require no comment.



A BELT HORSE-POWER DIAGRAM.

THIS diagram enables the determination of belt tensions and belt powers to be effected in an extremely simple and accurate manner according to the standard formulæ given below, and does away with the use of logarithm tables and practically all the calculations necessitated by the ordinary mathematical method of obtaining these values.

The Ratio of Belt Tensions.

If a belt drives a pulley in the direction shown in Fig. 1, T_2 being the tension in the lower or tight side, and T_1 the tension in the slack side, then when the belt is on the point of slipping (*i.e.*, the belt is transmitting the maximum power), the relation between these tensions is expressed by the well-known equation,

$$\frac{T_2}{T_1} = \epsilon^{\mu a} = \epsilon^{0.0174\mu A} \qquad (1)$$

where

ϵ = 2.718 (the hyperbolic logarithm base).
μ = coefficient of friction between the belt and the pulley.
A = angle of pulley embraced by the belt, expressed in degrees.
a = angle of pulley embraced by the belt, expressed in radians.

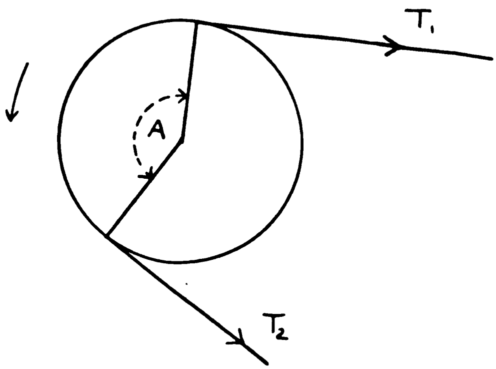


FIG. 1.

The value of μ for leather belts on iron pulleys may vary from 0.2 to 0.4, 0.28 being a good average value under ordinary working conditions. The angle A is, of course, fixed by the size and distance apart of the pulleys.

Given A, and assuming a value of μ, the tension ratio $\frac{T_2}{T_1}$ may be obtained immediately from the diagram by placing a straight-edge across the diagram so as to cut Scale I. (the angle scale) at the given value of A, and Scale II. (the friction co-efficient scale), at the selected value of μ, when the ratio $\frac{T_2}{T_1}$ is read where the straight-edge cuts Scale IV.

It follows that, given any two of the three values $\frac{T_2}{T_1}$, A, and μ, the third can at once be found.

The Power Transmitted.

Let F be the total frictional force between the pulley and the belt when the latter is just on the point of slipping, and V be the velocity of the belt in feet per minute.

Then F = $T_2 - T_1$, and the horse-power transmitted =

$$P = \frac{FV}{33{,}000} = \frac{(T_2 - T_1)V}{33{,}000}$$

$$= \frac{T_2\left(1 - \frac{1}{\epsilon^{.0174\mu A}}\right)V}{33{,}000}$$

$$= m\frac{T_2 V}{33{,}000} \qquad (2)$$

where T_2 is the maximum allowable tension in the belt, and $m = \left(1 - \frac{1}{\epsilon^{.0174\mu A}}\right)$.

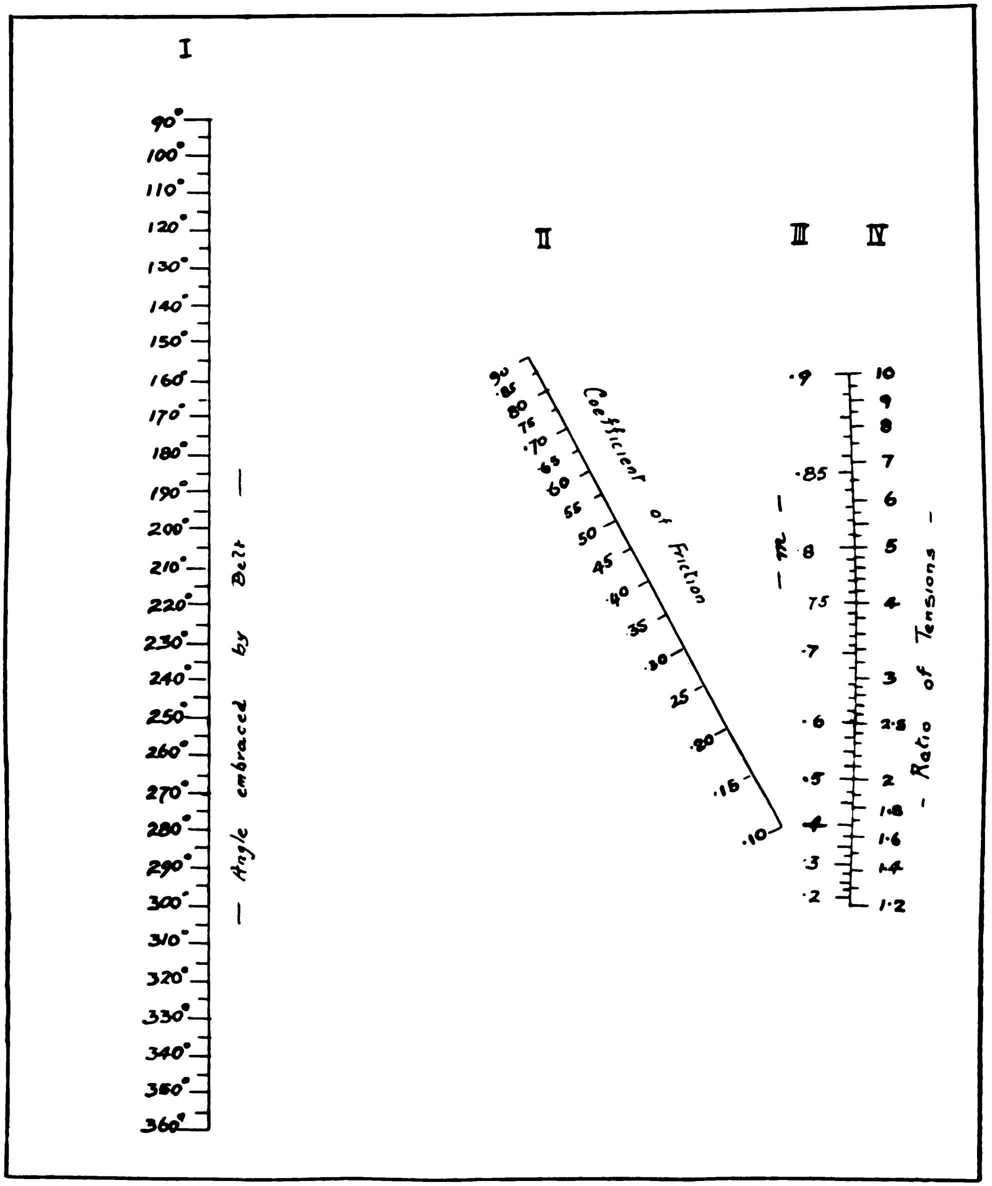


FIG. 2. A NEW BELT-POWER DIAGRAM.

To find, from the diagram, the horse power transmitted by the belt, place the straight-edge to the given values of A and μ on Scales I. and II. as before, but instead of reading $\frac{T_2}{T_1}$ on Scale IV., read the corresponding value of m on Scale III. The horse power P is then easily found by substituting this value of m in equation (2).

Example :

A = 180deg.
μ = 0.28.
V = 2000ft. per minute.

Width of belt = 6in.

Allowable tension per inch of width = 60lb.

$T_2 = 6 \times 60 = 360$lb.

Placing the straight-edge to 180deg. on Scale I. and 0.28 on Scale II., m is found to be 0.59.

Then $P = 0.59 \frac{360 \times 2000}{33,000} = 12.9$h.p.

It may be remarked that the diagram could be enlarged by the addition of belt speed and maximum tension scales, so giving the horse power directly on a third scale, but it is thought that the slight advantage obtained by the abolition of the simple calculation would fail to be sufficient compensation for the complication and inconvenient size of the diagram.

An improvement on the straight-edge would be a strip of transparent celluloid having a straight line engraved on the side touching the diagram.

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M.SC. TECH.

THE EVOLUTION OF WIRE.

It is highly probable that in early times metals were beaten with a hammer to thin plates which were afterwards divided into small slips, which, by means of a hammer and file, were rounded so as to form threads of wire.

In *Exodus*, *Chapter xxxix.* 3, we read that when the sacred dress of Aaron was prepared the gold was beaten and cut to threads so that it could be interwoven in the cloth.

In *Homer's* "*Odyssey*" it is told how Vulcan formed on his anvil, with hammer and files, a net so fine that it could be perceived by no one, not even by the gods themselves, for it was as delicate as a spider's web.

These fine wires were not drawn out, and in ancient writings, wherever spoken of, they appear to have been prepared on the anvil.

The first experiments in wire-drawing were made upon the most ductile metals, and it is certain that the metal was at first drawn by the hand of the workman.

While the work was performed by the hammer the men of Nuremberg were called *wire-smiths*, but after the invention of the drawing iron, they were called *wire-drawers*.

Conrade Celter, who wrote in 1491, speaks of the invention of a wire-drawing machine, driven by water, in which the axle-tree, by means of a lever, moved a pair of pincers that opened as they fell against the drawing plate and laid hold of the wire, which was guided through a hole in the plate. The pincers shut as they were drawn back, and in that manner pulled the wire along with them. Tradition has it that the son sold the father's secret: who would have put him to death had he not saved his life by leaving his home and country.

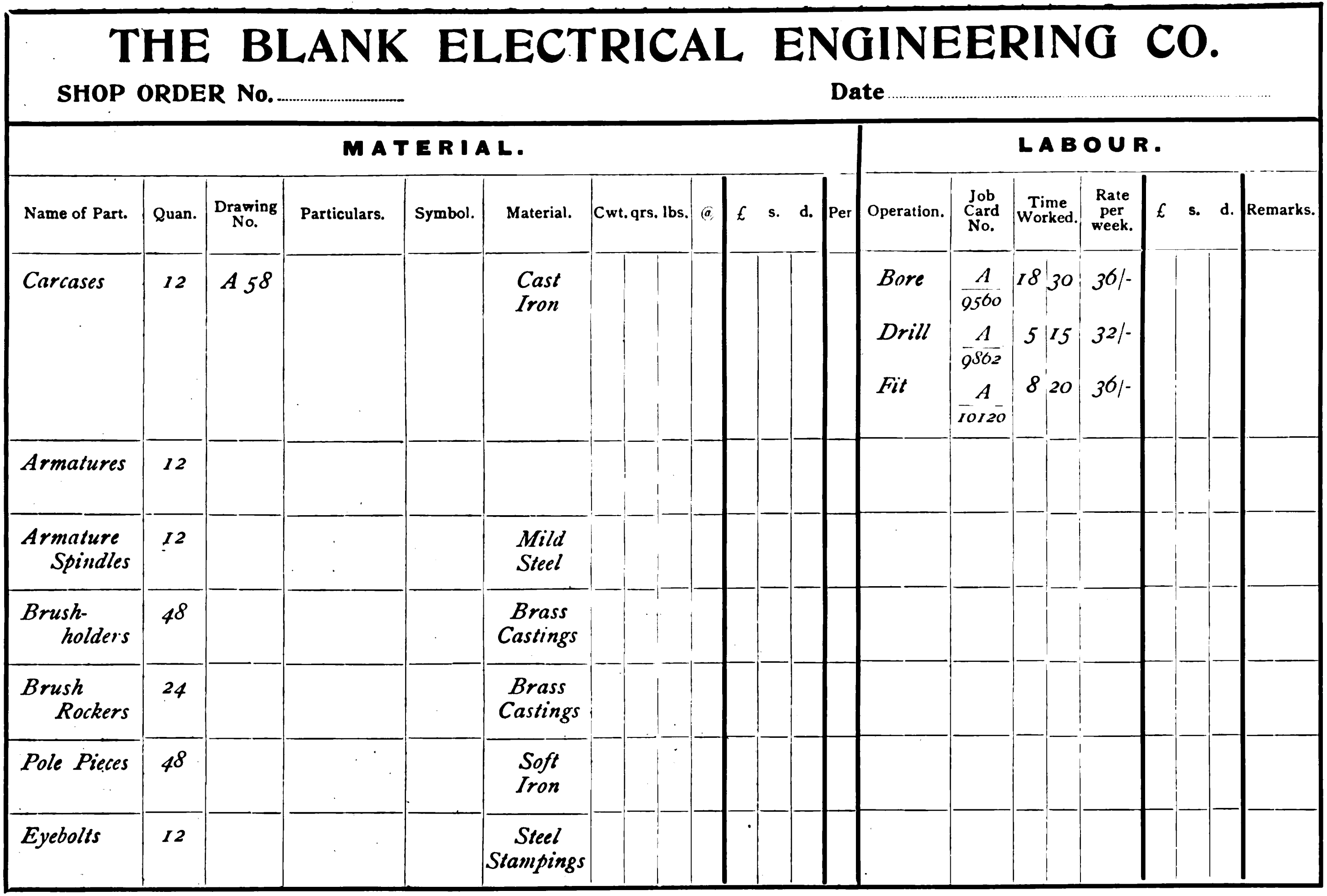
All the wire in England was manufactured by hand until the year 1565, when the art of drawing it was introduced by foreigners; and Anderson tells that a Dutchman constructed at Sheen, near Richmond, in 1663, the first mill ever seen in England.

A JOB CARD AND COSTING SYSTEM FOR ENGINEERING WORKS.

DURING the last few years competition in the engineering and kindred trades has become so keen that manufacturers who have to compete in the world's markets have turned their attention in a marked degree to the commercial departments of their works. The chief reasons for this are that these departments had been very badly neglected in the past, with the result that the employer himself did not know which department of his works was making a profit and which was working at a loss; and whilst expensive and up-to-date plant and machine tools had been installed in his works, he had no reliable method of ascertaining whether these tools were working to their maximum efficiency, nor discovering where the leakages were and thereby preventing a repetition of them in future; also, when estimating for giving in tenders for new work, a large amount of guesswork and uncertainty entered into the minds of the principals concerned, due to not having past records tabulated and other data at hand which would have enabled them to arrive at a figure within a very fine degree of accuracy, and with the glorious certainty of knowing they were somewhere near the mark, without having to add a large sum to cover incidental expenses and contingencies, &c., thereby probably losing the order on price.

With the up-to-date manufacturer this order of things is now changed; the old method of leaving everything in the hands of the shop foreman and workmen—who are in the habit of putting their time down in a careless and haphazard sort of way when they know there is no check upon them—has given way to more modern and efficient methods, the chief feature of which is the "job card" system of time-keeping and costing. When once a thorough system is installed on these lines it is remarkable the leakages it will expose from time to time; flagrant cases will quickly be shown up, which, under the old régime, where the workman put his time down to suit himself, would never have been brought to light. Where the work is of a standard nature the job card system is especially a means of comparison and cost reducing, but it can also be equally applied to works carrying on a varying and wide range of manufactures; it is very flexible, and can be easily adopted in any branch of the trade, whether the shops be large or small; and, whatever the extensions may be in the future, this system of time-keeping and costing can always be applied to any new department with the minimum amount of trouble and preparation.

Various time-recording machines have been installed in the majority of large engineering works during the last few years with varied degrees of success, although not many of them are of much benefit as a costing system, their chief function being to record the time the workmen enter and leave the works by a key or some other method, by which each man records his time as he passes the clock on entering his department. As the time is recorded to the minute by the clock there is no grace allowed at all in this case; but, on the other hand, the old-fashioned method of each man putting a round check, which is stamped with his number, in a slot, which is closed at the correct time by the time-keeper who is on duty, is very much quicker, and in very large works where several hundred workmen have to pass



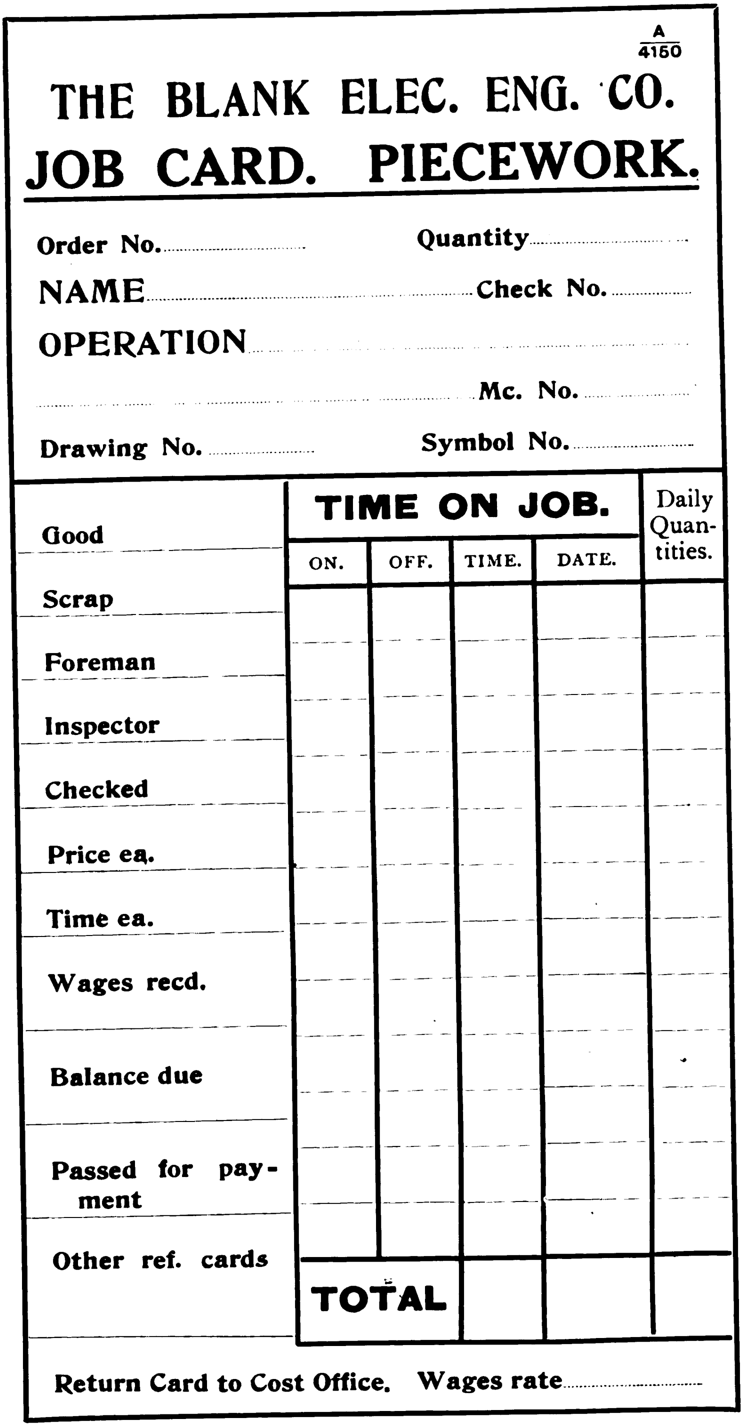
THE BLANK ELECTRICAL ENGINEERING CO.

SHOP ORDER No. ………………… Date ………………………………

MATERIAL.										LABOUR.					
Name of Part.	Quan.	Drawing No.	Particulars.	Symbol.	Material.	Cwt. qrs. lbs.	@	£ s. d.	Per	Operation.	Job Card No.	Time Worked.	Rate per week.	£ s. d.	Remarks.
Carcases	*12*	*A 58*			*Cast Iron*					*Bore*	$\frac{A}{9560}$	*18 30*	*36/-*		
										Drill	$\frac{A}{9862}$	*5 15*	*32/-*		
										Fit	$\frac{A}{10120}$	*8 20*	*36/-*		
Armatures	*12*														
Armature Spindles	*12*				*Mild Steel*										
Brush-holders	*48*				*Brass Castings*										
Brush Rockers	*24*				*Brass Castings*										
Pole Pieces	*48*				*Soft Iron*										
Eyebolts	*12*				*Steel Stampings*										

FIG 1. SPECIFICATION SHEET. 13IN. × 10IN.

through the same gate on entering, the latter method facilitates matters very much, and allows of a large number of employees entering in the minimum time. With the various mechanical time-checking clocks it is generally conceded that 200 is the maximum number to be recorded by a single clock, so that a works employing 1,000 hands would require four or five recorders. These recorders cost on an average from £30 to £40 each—quite a considerable item—whereas the round check system can be installed at a cost of a few shillings. Of course, with a recorder you have the advantage of knowing that the time cannot be tampered with in any way, and in addition you have got a permanent record of each day's time accurately recorded on a slip of paper, which can be read over at a glance at any subsequent date, whereas with the check system each man's time is entered on the time sheets by the time-keeper as he takes the checks out of their respective boxes; at the same time it must be borne



A
4150

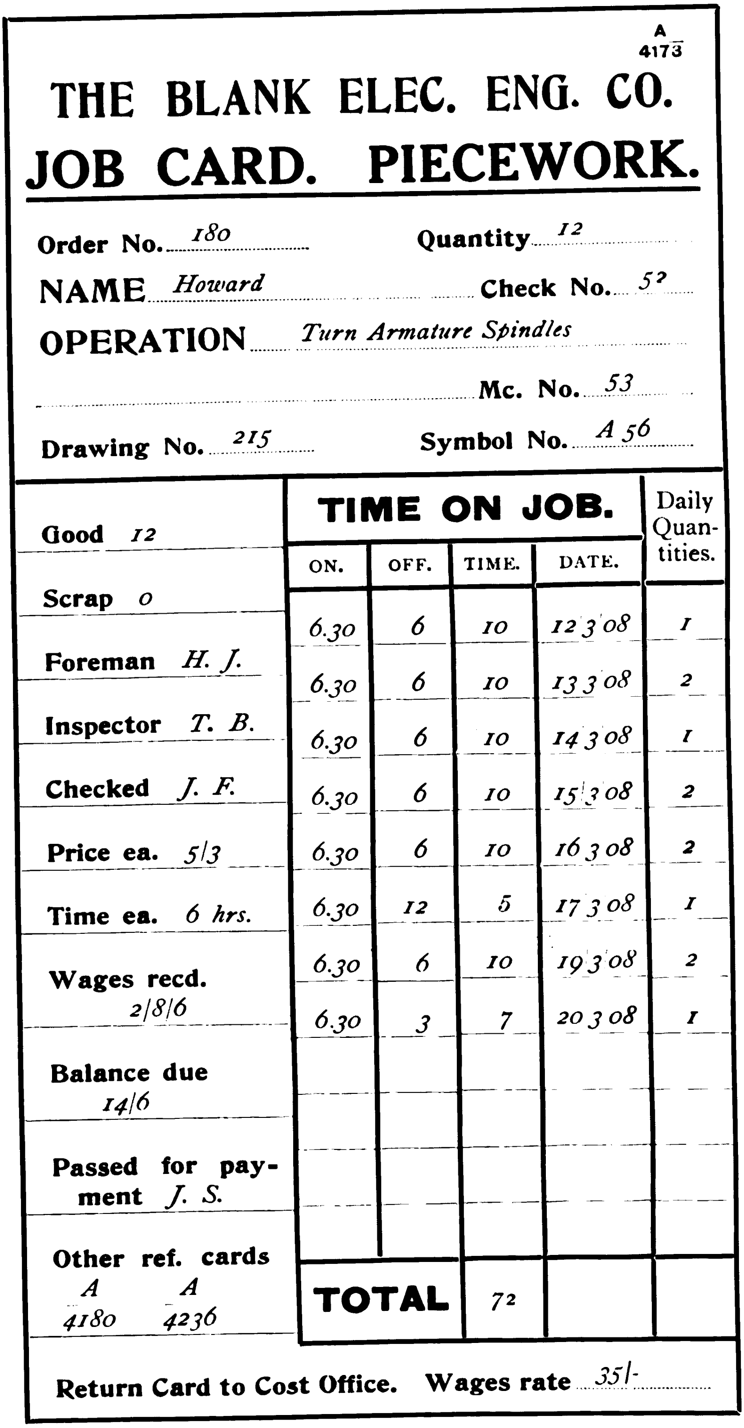
THE BLANK ELEC. ENG. CO.
JOB CARD. PIECEWORK.

Order No. .... **Quantity** ....
NAME .... **Check No.** ....
OPERATION ....
.... **Mc. No.** ....
Drawing No. .... **Symbol No.** ....

	TIME ON JOB.				Daily Quantities.
	ON.	OFF.	TIME.	DATE.	
Good					
Scrap					
Foreman					
Inspector					
Checked					
Price ea.					
Time ea.					
Wages recd.					
Balance due					
Passed for payment					
Other ref. cards	TOTAL				

Return Card to Cost Office. Wages rate ....

Fig. 2. Red Card. 4¼in. × 7in.



A
4173

THE BLANK ELEC. ENG. CO.
JOB CARD. PIECEWORK.

Order No. 180 **Quantity** 12
NAME Howard **Check No.** 52
OPERATION Turn Armature Spindles
Mc. No. 53
Drawing No. 215 **Symbol No.** A 56

Good 12
Scrap 0
Foreman H. J.
Inspector T. B.
Checked J. F.
Price ea. 5/3
Time ea. 6 hrs.
Wages recd. 2/8/6
Balance due 14/6
Passed for payment J. S.
Other ref. cards A 4180 A 4236

TIME ON JOB.				Daily Quantities.
ON.	OFF.	TIME.	DATE.	
6.30	6	10	12 3 08	1
6.30	6	10	13 3 08	2
6.30	6	10	14 3 08	1
6.30	6	10	15 3 08	2
6.30	6	10	16 3 08	2
6.30	12	5	17 3 08	1
6.30	6	10	19 3 08	2
6.30	3	7	20 3 08	1
TOTAL		72		

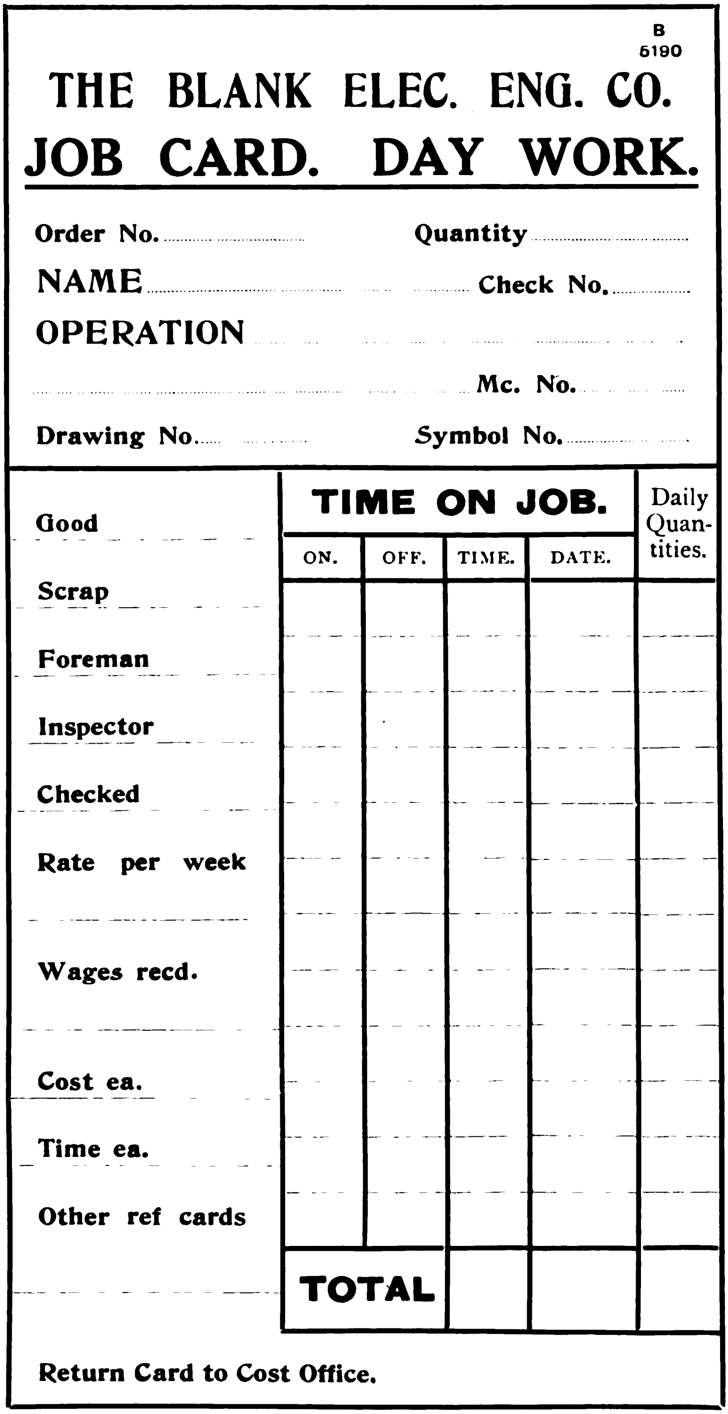
Return Card to Cost Office. **Wages rate** 35/-

FIG. 3. RED CARD. 4½IN. × 7IN.

in mind that this clerical work has also to be done with a time-recorder system before the wages are paid.

Now that the workman has recorded the time at which he commences duty, it becomes apparent that his employer must utilise the best means at his disposal to keep him fully employed on profitable work, with as little lost time as lies in his power. When the workman has the responsibility of making out his own time-sheets daily without any check, not much reliance can be placed on them, and it is no easy matter to know how the time has been utilised, and whether it has been allocated to its correct shop order number—an important factor. With the job card system all the clerical work involved in making out the daily time returns is taken entirely away from the shop operator, and the responsibility given to one man equipped and set out for the work—the shop superintendent's job clerk, whose sole duty it is to see that each and every man's time is properly recorded on every job he completes, whether it be day, premium, piece, or bonus work. The job clerk sits at a desk in a convenient position in the shops, and has a rack in front of him carrying as many pigeon-holes for his job cards as there are employees under his charge, each hole being numbered the same as the workman, so that each operator has his own pigeon-hole for his job cards.

All work to be manufactured for sale should be produced under a shop order number, whether it be for stock or made to individual orders, so as to allow the time expended on it to be booked to it and charged against it. For instance, should it be decided to put an order through the shops for twelve 10h.p. motors, they should have a shop order number allocated to them, and be manufactured under that number, and a specification sheet issued from the drawing office to the job clerk, storekeeper, and works superintendent, containing a full specification and particulars of materials and quantities required, as shown in Fig. 1. These specification sheets have



B
6190

THE BLANK ELEC. ENG. CO.

JOB CARD. DAY WORK.

Order No............................... **Quantity**..............................

NAME.............................. **Check No.**..................

OPERATION..............................

.... **Mc. No.**..........

Drawing No............... **Symbol No.**..............

Good

Scrap

Foreman

Inspector

Checked

Rate per week

Wages recd.

Cost ea.

Time ea.

Other ref cards

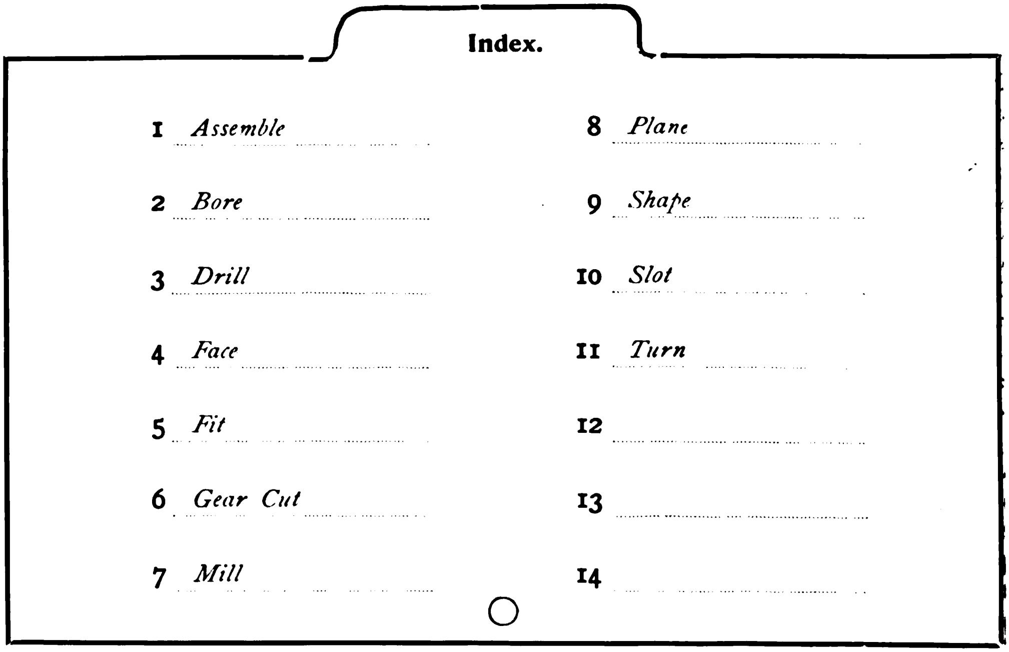
TIME ON JOB.				Daily Quantities.
ON.	OFF.	TIME.	DATE.	
TOTAL				

Return Card to Cost Office.

Fig. 4. White Card. 4½in. × 7in.

all the headlines printed, and only the specification and quantities and material are entered by the drawing office specification clerk, the sheets then being issued to the shops. The job clerk then commences to start the workmen on the various jobs, the foreman or superintendent giving the men instructions what operation they are to perform, and also informing the job clerk, who immediately makes out a job card containing full particulars of the operation, and also quantity required. This card is issued to the workman concerned, and the clerk records it on the specification sheet as shown, opposite the component part put in operation. On looking at the specification sheets he can thus see at a glance what parts are in progress. As each man finishes his operation he brings his job card in, gets it signed off, and gets signed on another card at the same time, thus avoiding loss of time and waiting between jobs—no small source of waste in some shops.

Should the man be engaged on piecework a job card similar to the one shown in Fig. 2 is very suitable. This contains all the essential features which go to make it as near fool proof as possible, although these cards vary very much, each firm having various ideas embodied on their cards—some of them not much better than the old-fashioned chalked time-board. The chief features of a job card to make it of any benefit as a record for future reference are that they should each be numbered consecutively, from 1 up to, say, 20,000, and in series, as in Fig. 2—which is A series, card number 4150. When 20,000 has been reached commence again at B series, until the alphabet is finished, then other symbol letters can be used, such as A.A., &c., all the other particulars contained thereon, such as name, quantity, drawing number, piece or symbol number of part, and machine number, if it be a machine operation: each machine tool in the shops bearing a plant register number, of which a schedule is kept posted up in front of the job clerk for this purpose. This may seem superfluous and unnecessary

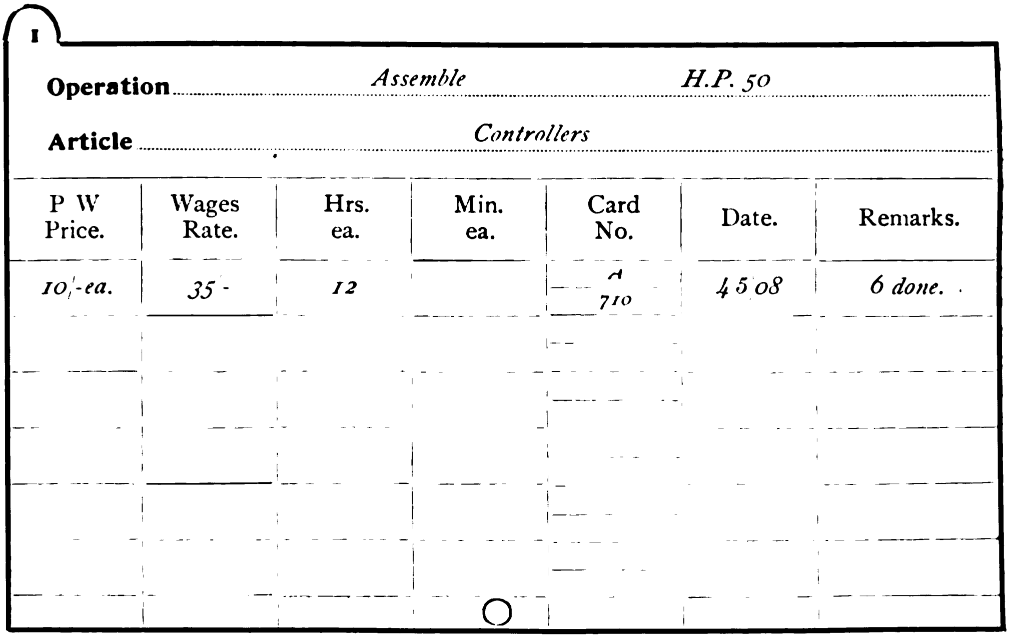


Index.

1 *Assemble*
2 *Bore*
3 *Drill*
4 *Face*
5 *Fit*
6 *Gear Cut*
7 *Mill*
8 *Plane*
9 *Shape*
10 *Slot*
11 *Turn*
12
13
14

○

Fig. 5.



1

Operation *Assemble* *H.P. 50*

Article *Controllers*

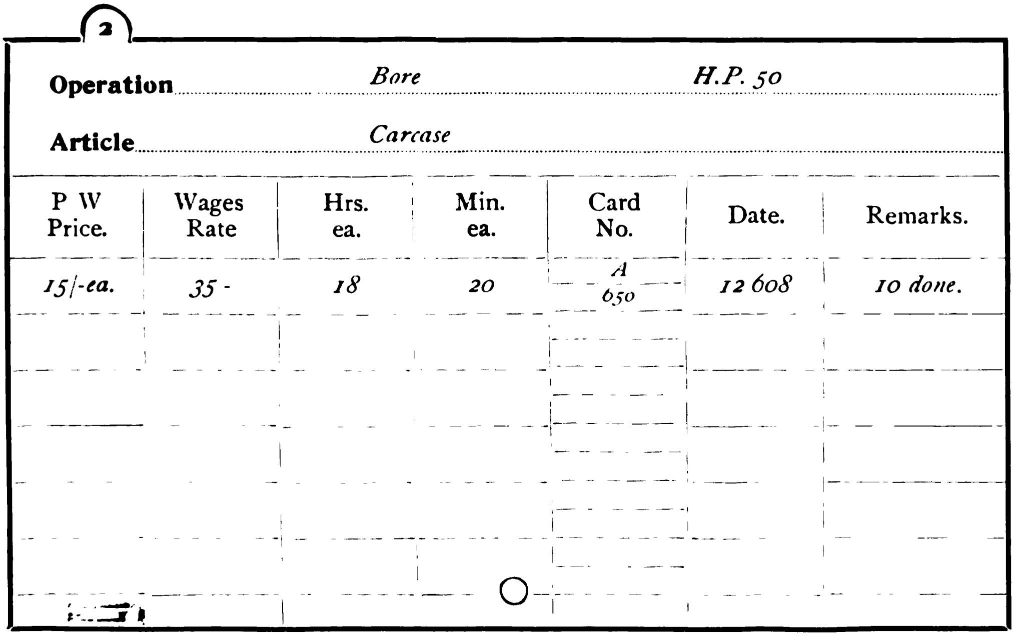
P W Price.	Wages Rate.	Hrs. ea.	Min. ea.	Card No.	Date.	Remarks.
10/-ea.	*35/-*	*12*		*A* *710*	*4 5 08*	*6 done.*

Fig. 6.

to some works managers, but any job card without it is incomplete, and it often plays a very important part when deciding which machine or tool is the most suitable for doing the job in future, as the most efficient machines for the job can be easily ascertained upon a comparison of job cards, and they very often present some very interesting facts. On the piecework cards the price allowed is entered by the rate-fixer when the man commences on the job. If it be a new job the price will have to be arrived at by calculation and analysis, and by the judgment of the rate-fixer (who should be a practical man), subject to the approval of the works manager or superintendent. Each morning when the workman enters the works he is booked on his job card and all the cards are collected in every night by the job clerk's boy and booked off, and the quantity completed that day is entered in the column provided for that purpose; thus any erratic or spasmodic production or effort on the part of the workman can be detected by looking down the quantity column. As a check on the job clerk a time clerk goes round every morning checking the previous day's times and balancing them with the time-sheets for wages payment at the week-end. As each job card is returned to the job clerk completed he totals the time up and passes it on to the foreman for his signature, who in turn passes it on to the inspection department, who have the inspection of the quality of work and who finally pass the cards on to the cost department every morning. The cards are checked in the cost department and passed for payment, anything erratic being brought to the notice of the works superintendent. Should a gang of three or four men be employed on one and the same job their respective job cards are cross-referenced to each other, as shown in the "other reference cards" column in Fig. 3, so that the totals may be added together to arrive at the complete cost.

Should the operator be employed on day work a suitable job card is shown at Fig. 4, which contains all the important features for future reference. These cards are generally printed on different-coloured material from the piecework cards, so as to make them distinguishable at first sight.

After the job cards have been extended and checked in the cost department they are passed on to the rate-fixing department for their perusal, and a record is taken from them of any information necessary for the future benefit of that department. For this purpose a card index system is the most concise and up-to-date. The compact cabinets sold for this purpose are well known, and when they are properly organised and arranged any single record required can be located in a few seconds. These index cards are now adapted to suit the requirements of every trade, and the different columns for recording information thereon are worded to suit requirements. To facilitate turning up the correct cards an "index to operations" simplifies matters very much in the rate-fixing department; that is, each operation in the shops is classified alphabetically, as shown by the index card on Fig. 5. One of these index cards should be kept in the front of every box for reference, as shown in Fig. 8. Next to the index to operations comes the master card, as shown in Fig. 8, which locates the part by having the name written upon the tab as shown; these should run alphabetically along the cabinet. After each master card come the small tab cards, with the operation numbers on, as shown in Figs. 6, 7, and 8. After the rate-fixing department has recorded the necessary information the job cards are finally sent back to the costing department, and they are filed away numerically, in bundles of 1000 each, in any convenient position. When the job in the shops is completed the specification sheets are returned to the cost department also, the storekeeper having entered the material in the columns provided for that purpose, and the job clerk the job card numbers. The job cards, which will have already been paid wages on and filed away in order, are got out by a boy, he reading the numbers off the specification sheets. The amount on the cards is now transferred on to the specification sheets in



2

Operation *Bore* *H.P. 50*

Article *Carcase*

P W Price.	Wages Rate	Hrs. ea.	Min. ea.	Card No.	Date.	Remarks.
15/-ea.	*35-*	*18*	*20*	*A 650*	*12 608*	*10 done.*

Fig 7.

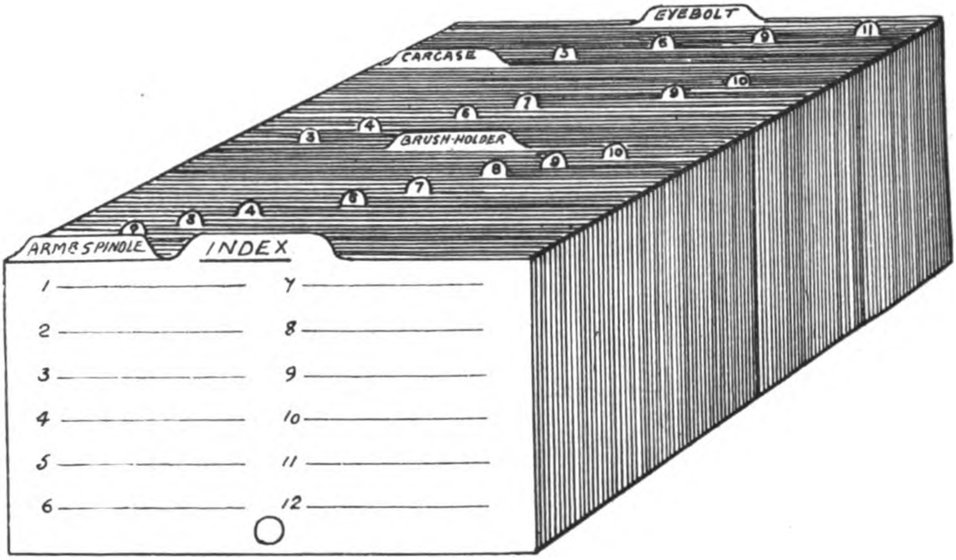


FIG. 8.

the columns provided, and totalled up at the bottom. Thus an accurate cost of production is obtained, as the clerk sees that no man is allowed to work without a job card, and also that no man has two cards out at the same time—in fact, each man must produce his card for his completed job to be booked off before he can get another card issued to him. This system may seem complicated and expensive, but, once established, it works very smoothly and at little cost, as one job clerk and a boy can easily make the cards out and keep the time correctly and see they are entered on the specification sheets, for a shop of 250 to 300 men, whereas, if each man put his own time down, in the aggregate the time taken would amount to much more than the job clerk's wages come to; and, moreover, it is always advisable to relieve the shop operator from as much clerical work as possible, for several reasons.

When a permanent record is obtained on a job card and it is turned up for comparison (which it can be in a minute or less at any time, if the card number is entered on the rate-fixer's card index), it will be seen at once which men and machines are the most efficient on particular classes of work. Here, then, is a check against excessive time being taken on jobs as they come along, and if the workman knows you have accurate records of former performances he will make a special effort to keep up to the standard; and as the number of the machine on which the same job was previously done is entered on the card the employer can form an idea as to which machine is the most rapid and efficient. In fact, the job card system keeps both workman and machine tool up to concert pitch, by indicating the extent and position of the leakages. The old job cards also, when filed away, are valuable for estimating purposes, as they contain actual records of time taken to complete the jobs in hand, particulars of which are entered on the card.

While some firms keep their manufacturing costs on a sound basis, great leakages occur in the works engineer's department, which deals with plant repairs and renewals; and also in the tool-room. These departments, not being employed on manufacturing work for sale, should have a proper system of recording their

PLANT LEDGER ORDER BOOK.

Order No.	Plant Ledger No.	Drawing No.	Job Card Nos.			Dates		Remarks.
						Issued.	Completed.	
	580	*C230*	*A* *1870*	*A* *2110*	*A* *2114*	*3/5/08*	*1/6/08*	*Make one 2in.*
								reamer with
								solid shank.

Fig. 9.

time and booking it to the various jobs and proper shop order numbers, just the same as the manufacturing departments. For this purpose a plant ledger order-book should be kept by the works engineer and tool-room foreman, the ruling of which should be similar to that shown in Fig. 9. Every order for a tool to be made or a machine repair is given by the authority and entered in the plant ledger, and every order should have a plant ledger consecutive order number, as shown in the second column, only the special tools or work requiring to be charged to any certain shop order number being entered in the first column. For instance, a 2in. standard reamer would be used on all standard work, and would not be charged to any special order number. The job card numbers are entered opposite their respective jobs in this ledger, just the same as on the cards, by the job clerk, and when the job is completed it is ruled off by the foreman and the book goes across to the cost department once a month to have the plant account totalled up and posted to the plant ledger account; thus a record is kept of all the time taken on plant repairs, renewals, all tools, jigs, &c., made, just the same as if it were expended on work for sale. By these methods the factory charges—that is, as far as the works engineer's department and tool-room are concerned—are easily arrived at within a very fine degree of accuracy, instead of in the slipshod manner which is so pronounced in these departments in some works where a true cost of any work produced in these departments is rarely obtained.

Most firms who make a feature of a costing system have a separate departmental number for the different sections of their works, so as to allow of the proper allocation of oncost and factory charges, instead of the old method of charging a fixed sum of, say, 75 per cent. on actual labour costs throughout the whole works. For instance, the factory charges or hourly burden are considerably higher in a machine department than in a fitting or assembling department, as no power is required in the latter, nor such an expensive equipment of tools, cutters, &c., with their consequent depreciation; therefore the factory charges for a capstan or turret lathe department should be considerably more than a fitting department, and the same applies to a gear-cutting department where an expensive equipment of cutters has to be kept sharp. Thus the departmental numbers would run similar to: turret and capstan lathe department, 1; gear-cutting, 2; grinding, 3; pattern shop, 4; smithy, 5; foundry, 6; painting, 7; boilermakers, 8; &c., some firms having upwards of thirty departmental numbers. These departmental numbers are generally written on the job cards, a copy of the numbers of each department being kept by the job clerk. They can then be charged up to the proper department when the cost clerks are dealing with them. By a careful analysis of the departments from time to time it can be shown which particular departments are working at a loss, and machinery set in motion for remedying the fault.

Some employers begrudge the money spent in costing their work, cost clerks being non-producers; but it is now an acknowledged fact that "system does pay" when properly carried out, and although it may require one or two additional clerks on the staff, the increased output from the men obtained by the management having the leakages brought to their notice and taking steps to prevent them in the future more than pays for the extra wages in the staff departments.

SEARCHLIGHT PROJECTORS.

So much has been achieved in the development of the searchlight, that the latest projectors bear but little similarity in features or in size to the very early types. The writer proposes to give a short historic sketch of their uses and growth, including the numerous improvements which have brought the projector up to its present position of efficiency and utility. Projectors have been largely used for naval and military purposes, for night observations, and signalling, the latter operations being mainly carried out on a semaphore or Morse code system. An early type of projector designed for night signalling by use of a semaphore system is illustrated in Fig. 1, using a lamp with vertical carbons, as against the more modern lamps with horizontal carbons and flashing shutter. The construction of the lamp and body is characteristic of the early projectors; modifications are made with regard to the front, which allows of the direct issuance of the light-ray's, the barrel is provided with an octagonal pyramidal reflector placed in the path of the light-rays, and having the apex of the pyramid facing the light. The sides of the pyramid are arranged to make an angle of 45deg. with the base. The effect of such an arrangement is that the light falling on the reflector is split up into eight beams, which are caused to travel in a direction at right angles with the original beam. The beam which travels vertically downwards not being required in practice, the corresponding reflector is omitted, so that seven beams are formed corresponding to the seven positions of the semaphore system. The beams of light are operated by doors or shutters on the external shell, which cover up the corresponding apertures, usually fitted with a concentrating lens to cause the rays to issue in a parallel beam. The doors or shutters can be worked electrically from a distance, or by hand by a suitable arrangement of levers. Many arrangements of mirrors have been devised for operating a system of semaphore signals as described above. Provision has also been made for injecting into the beams of light jets of steam, smoke, water, or vapour, with a view to rendering the beams more clearly defined.

The optical part of a projector being obviously of great importance, considerable attention has been given to various forms of mirrors, the most efficient and recent being the parabolic mirror, constructed of crystal glass, or, more recently still, of metallic construction, other notable forms of mirrors being the Mangin, aplanatic, and spherical. It is not accurately true, in the case of the latter, that all rays parallel to the axis meet at a point (the focus), and this irregularity (which is found in lenses also) is known as "spherical aberration." If the pencil of rays is small they may practically be supposed all to pass through the focus, but for wide pencils this is only so in the case of parabolic mirrors; hence their use for projectors. Parabolic reflectors were used as far back as 1763, or at any rate as far back as 1777, for lighthouse illuminations by a Mr. Hutchinson, of Liverpool. These mirrors were formed of small facets of silvered glass made up as nearly as possible to a parabolic curve.

The most important improvement from an optical point of view is the substitution of the gilded metallic mirror for the silvered glass mirror, either Mangin or parabolic. In the production of good metallic reflectors it has been necessary

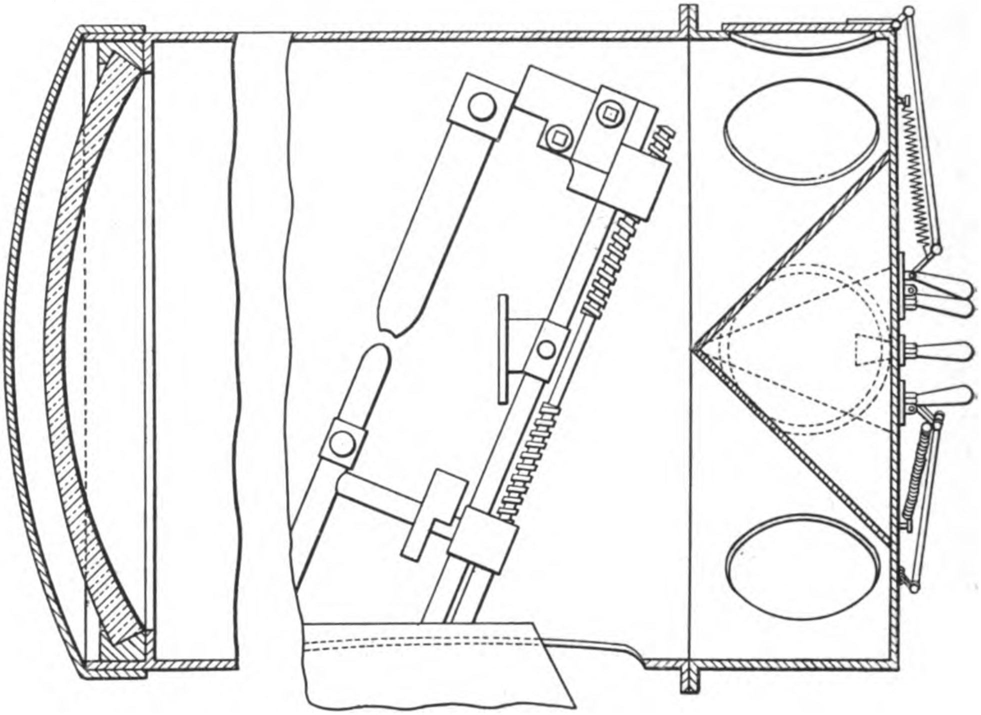


FIG 1. EARLY FORM OF PROJECTOR WITH FLASHING SHUTTERS.

to overcome numerous difficulties, notably those incidental to the design and construction of special machines for working up the parabolic metal pieces, as machines formerly used for glass mirrors could no longer be employed. After working up, the mirror should be polished carefully and covered with a fairly thick deposit of gold, all of which presents difficulties corresponding to the dimensions of the mirror. Experience has shown that gold-coloured metallic mirrors in clear weather give results comparable with glass mirrors, and as soon as the weather becomes foggy the gilded reflectors are superior to silvered glass. The advantages of metallic mirrors from a military point of view are incontestable. They present, besides a complete resistance to variations of weather and temperature, the advantage of withstanding shocks from gun fire, and they can be pierced by bullets without the intensity of the beam being sensibly diminished. A further advantage in favour of metallic mirrors is that of weight, they being considerably lighter than glass mirrors. The weight of a 26in. metallic mirror is approximately 30lb., whereas that of a glass mirror of the same size is about 165lb. The employment of metallic mirrors also permits of much shorter focal lengths than are permissible with glass mirrors, owing to the intense heat generated, which would result in blistering the silver on the mirror, or even breaking the glass if in close proximity. Having found that, especially with horizontal carbons, the central zone of the mirror is practically useless, a central aperture is made in the mirror with a view to render more efficacious the ventilation of the silvered surface (in the case of glass mirrors); this also facilitates the manufacture, and enables the mirror to better resist air pressure due to the discharge of heavy guns. Mirrors, whether of metallic construction or of crystal glass, are usually

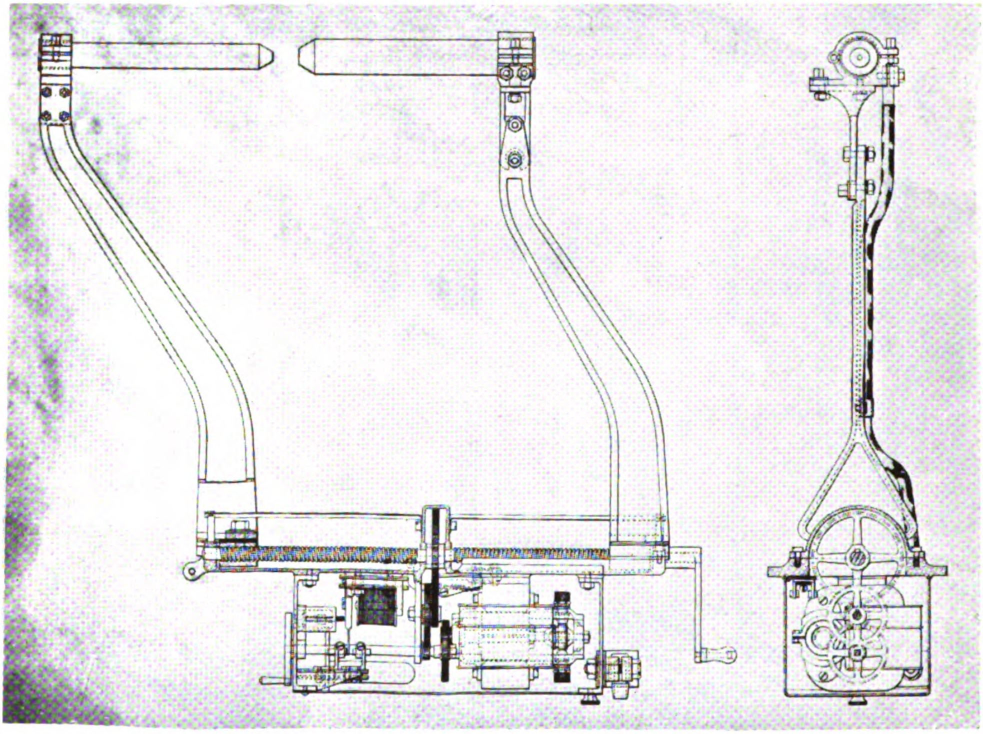


Fig. 2. Mechanism of Modern Motor-driven Projector.

fixed to the body of the projector in an easily detachable frame, to allow of rapid inspection and cleaning operations.

One of the earlier methods of focussing a projector lamp was to move the mirror in relation to the arc, the mirror being mounted in a movable frame or carrier arranged to move parallel with the axis of the projector. The later and more approved method is to move the lamp in relation to the mirror. This is usually accomplished by having the lamp mounted on guides or runners and attached to an adjusting screw or handle, by means of which the lamp can be moved in either direction at will. This arrangement has the advantage of rapid manipulation, and it can also be used to produce a divergent beam. This is obtained by varying the relative distance between the arc and reflector, which can be done by a few turns of the handle supplied for that purpose, the movement changing the light from a straight beam to a widely-divergent beam or vice versa. A much more effective method lies in the use of dispersion lenses, sometimes called "divergers," which consist of strips of plano-convex glass set in a suitable frame for slipping over the front of the projector, or arranged to swing across the beam of light. The light in passing through these strips is first converged, or brought together, and then, as the rays cross, they spread out again and continue to spread indefinitely. The effect when placed in front of a searchlight is to spread the light out in the shape of a partly-opened fan. The light is spread out horizontally, but not vertically. The light when thus spread is not so penetrating as a parallel beam. Many forms of dispersion lenses are arranged in a separate ring or mounting, which, when required, has to be fixed over the main glass door. This has always been a troublesome operation, and after being used a few times the usual practice has been to put the dispersion lens door carefully away and never use it again, notwithstanding the great convenience resulting from its use. A novel method of fixing dispersion lenses inside the barrel has been adapted on some projectors of American design. The lenses in question are arranged in two semi-circular brass rings so pivoted that they can be swung around a vertical axis. On the top of the barrel are provided two brass handles, by means of which the lenses may be swung into position or out, as desired. This takes but a few seconds, and the front door need not be opened. The dispersion lenses when out of use lie in a vertical plane parallel to the beam, and, being of very small section, do not interfere with the efficiency of the beam to any appreciable extent. The usual angles of divergence for, say, a 24in. projector are 16deg., 20deg., and 30deg., other angles being easily obtainable for special requirements. Modifications in dispersion lenses to meet the requirements of the Suez Canal regulations stipulate that all ships traversing the Canal at night by means of searchlights shall project a beam of light forward which shall have a shadow in the centre of 5deg. divergence.

The bifurcated beam thus required has been produced in several ways, some designers preferring a system of metallic strips or shutters placed in front of the dispersion lenses, while others prefer a series of prismatic lenses.

Flashing Gear.

This can generally be brought under one of two classes—internal or external. The internal flashing shutters were mostly used in conjunction with the vertical carbon lamp, and were usually in the form of a plate or disc of suitable shape arranged to intercept the rays of light between the arc and the mirror. Flashers of this type had numerous drawbacks, the most prominent being the formation of shadows in the beam when the flasher was out of use. These shadows were caused by the flasher plate or its fixings coming within the cone of rays thrown on the mirror by the arc, so that the efficiency of the beam was materially affected. Also the more

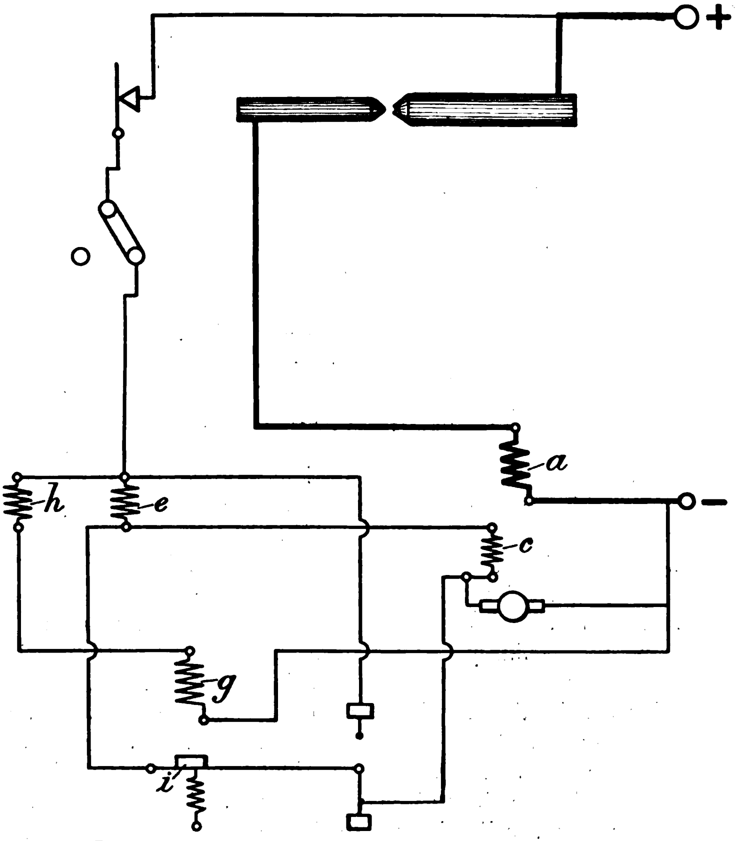


Fig. 3. Diagram of Connections of Motor-driven Projector.

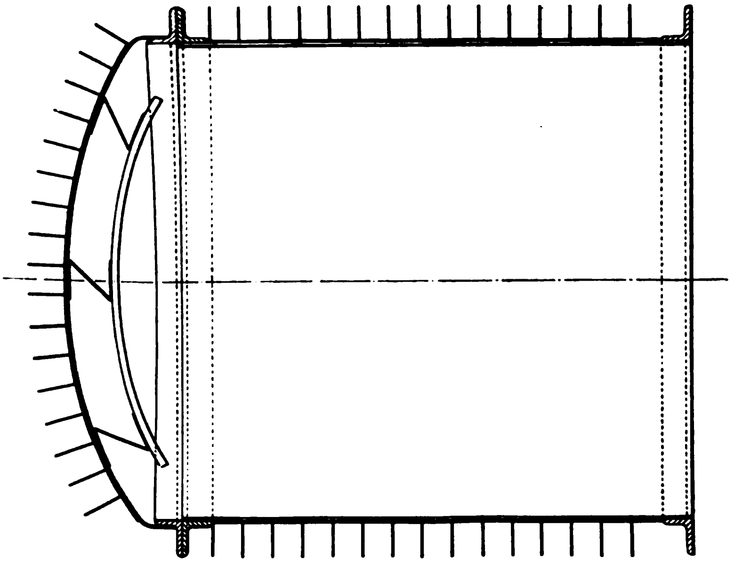


FIG. 4. SYSTEM OF COOLING THE LAMP AND MIRROR.

general use of projector lamps with horizontal carbons makes it difficult to design any really good arrangement of internal flashing gear. The external flasher, consisting of a series of Venetian shutters in front of the door, entirely eliminates this trouble.

Projector Lamps.

The earlier types of projectors nearly all used a lamp in which the carbons were in an inclined position; the result was that the carbons, carbon-holders, and supports caused very bad shadows in the beams of light. The horizontal carbon lamp is now almost universally adopted for projectors. The use of this type of lamp materially adds to the efficiency of the projector, in so much that there are no bad shadows produced on the mirror. The lamps are usually of the differential type, operated by a shunt and a series coil, much in the same way as an ordinary vertical arc lamp, the feed mechanism necessarily being modified to suit the requirements of a horizontal position. The carbons are fed by means of a screwed rod having a right and left hand thread, and actuated by means of a shunt coil through suitable pawl mechanism. Motor-driven projector lamps have been in use, mostly on the Continent, for some fifteen to twenty years, but for various reasons they have not come much to the front.

Through the courtesy of Messrs. Clarke Chapman, of Gateshead, the writer is able to illustrate, in Figs. 2 and 3, one of their latest and most modern motor-driven projector lamps, Fig. 2 being the lamp in section and Fig. 3 being the diagram of connections. The lamp comprises a compound wound motor, connected through suitable reduction gear with a right and left hand screw moving the carbon carriers. From one of the gear wheels a spindle is carried to the end of the lamp-box, and has a hand wheel mounted on it to enable the carbons to be controlled by hand when required. The motor has two windings on its magnet, one being in series with the carbons, and carrying the current passing through the arc, the other being in series with the armature and a fixed resistance, and forming a shunt across the terminals of the lamp. The two magnet windings oppose each other, the one carrying the main current tending to rotate the armature so as to separate the carbons, and the shunt winding tending to rotate the armature in the opposite direction.

A relay magnet G is also provided and connected across the terminals of the lamp through a fixed resistance H. The relay magnet attracts an armature against the pull of an adjustable spring and causes a contact arm to break contact with one point and to make contact with another.

Referring to the diagram of connections, it will be seen that when the relay armature is not attracted the contact made by the arm and point short-circuits the shunt circuit magnet winding (c) of the motor, and when attracted the arm leaves this point and makes contact with another point, the effect being to remove the short circuit from the magnet coil and to short-circuit the resistance e placed in series with the magnet coil.

The amount of excitation given by the shunt current magnet coil is approximately double that of the series coil a when normal current is flowing through the arc, and the resistance placed in series with the shunt current magnet winding and the armature is approximately equal to the resistance of the magnet winding. Therefore, when working, the series coil would operate to separate the carbons as long as the relay armature is not attracted, and when the relay armature is attracted the shunt current winding would be excited, and, overcoming the series winding, would operate to approach the carbons. Owing to the resistance of the shunt magnet winding and the fixed resistance being approximately equal, the current in the armature winding would remain of about constant strength when either the magnet winding or the resistance is short-circuited by the relay contacts. When, with normal current through the arc and normal voltage across the lamp terminals, the relay armature takes a midway position, then neither the resistance nor shunt magnet winding would be short-circuited, and, both magnet windings then being of equal strength and acting in opposition, no movement of the motor armature would take place.

A hand switch is provided to open the circuit of the relay and shunt current through the motor when it is desired to work the lamp by hand, and a trip switch is also placed in the box, performing the same operation when one of the carbon carriers arrives at the position it would occupy when the carbons were nearly all consumed.

The use of flame or mineralised arcs necessitates a different form of mirror and different controlling mechanism. The flame arc projectors, and also the use of petrol-oxygen in projectors, the writer hopes to deal with at a future date.

In consequence of the excessive heat generated by the electric arc it has been necessary to give special attention to the ventilation of the projector body and mirror. When projector lamps are con-

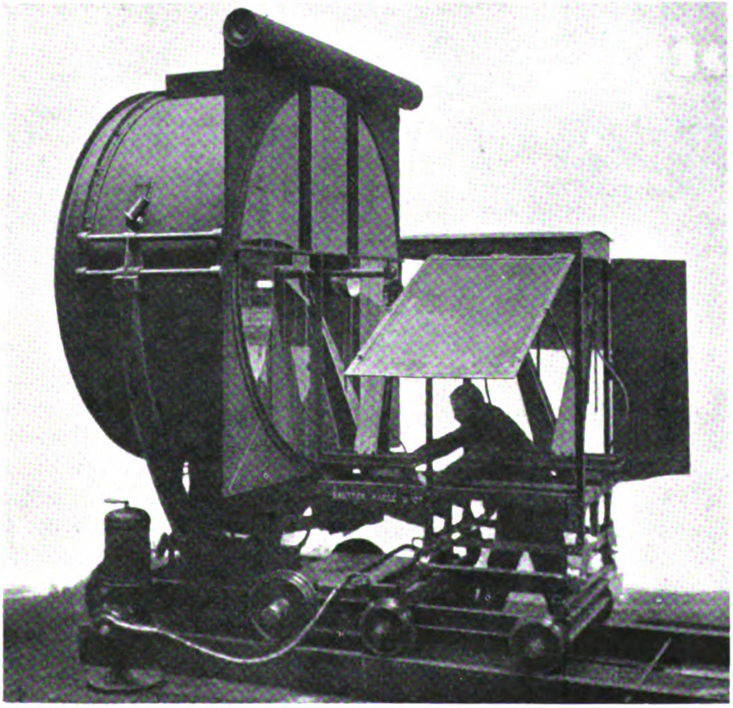


Fig. 5. Projector for Coast-defence Service.

suming current up to 200amp. it will be readily appreciated that some means must be provided to carry away this heat. It may be mentioned that a metallic mirror, after being a considerable time in use, reached a temperature in the neighbourhood of 700deg. F., with an arc taking approximately 180amp. The heating up of projector bodies and fittings, more especially in the case of small projectors, and even large projectors when used in a sheltered position, is a source of trouble in handling, and is always dangerous in the case of crystal glass mirrors.

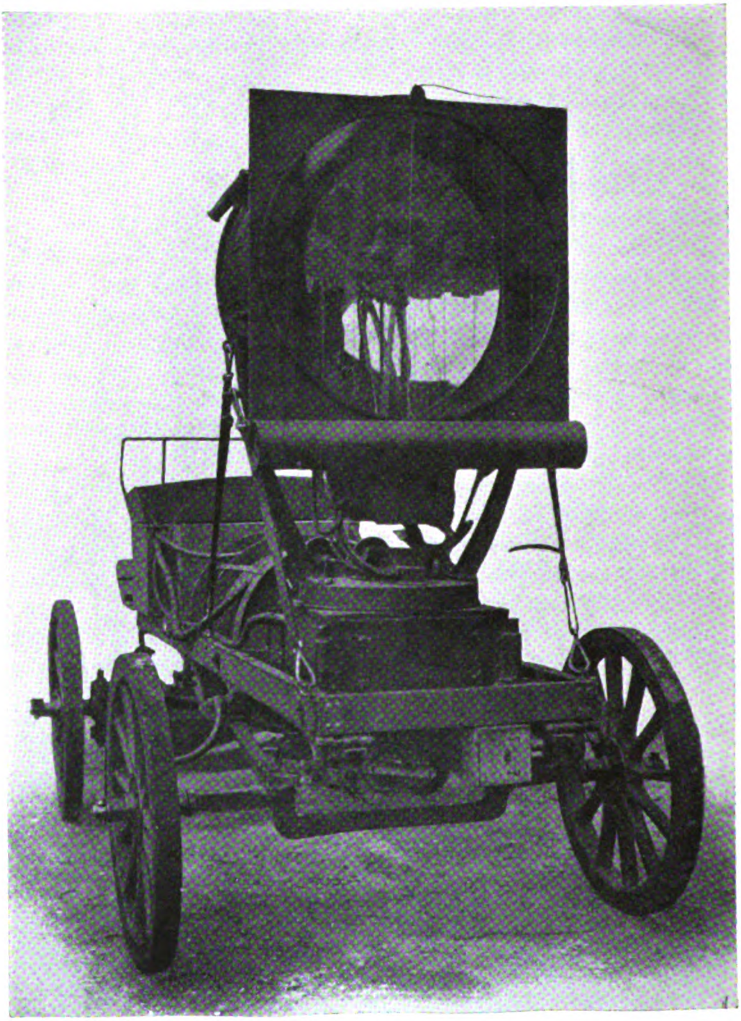


FIG. 6. PROJECTOR FOR FIELD SERVICE.

A suggested method of cooling the barrel was recently brought before the writer's notice. It consisted of ribbing the barrel with light angle sheet 1-16in. thick, and also the back of the mirror frame. In the case of the latter special flat plates were allowed to lightly press against the mirror (metallic mirrors being used) as a means of rapidly conducting the heat to the ribbed cover which materially lessened the temperature rise of mirror and barrel. Of course, the ribs on the barrel were omitted where doors, ventilations, and other mountings interfered with their use. It was claimed that the radiating surface of the projector body was increased 75 per cent. by the webs. A rough sketch of such a method is shown in Fig. 4, the usual ventilating hole being omitted in the sketch. A further advantage is the use of wooden handles, or, to be more correct, iron handles, with a wooden covering or sleeve, on mirror frames and front glass doors, as the usual iron handles become too hot to be comfortable when in prolonged use.

Mechanical Movements of Projectors.

The balancing of the projector body on its trunnions is usually accomplished by having one of the trunnion guide rods screwed and passing same through a screwed hole in the trunnion bracket at each side of the barrel.

Any movement of the barrel parallel to its axis can be made by revolving the screwed trunnion rods. It is preferable that the screwed rods should be coupled together by chain gear or other approved means whereby both rods revolve at the same time, keeping the barrel quite parallel with the guide rods. This is of the first importance on military projectors, where adjustments of the barrel have to be made rapidly and often in action. The movements of the projector barrel through 30deg. above and below the horizontal and the describing of a complete circle by the turntable are accomplished by means of worm gearing, which is so arranged that it can be thrown out of action should it be desirable to manipulate the projector rapidly by hand.

Various friction plates and clamping screws are in vogue for stiffening the movements of the barrel and base when operating the projector by hand. Difficulties sometimes occur with devices of this kind, inasmuch as the operator often throws out the worm gearing for obtaining the slow motion before sufficiently tightening up the clamping plates, the result being that the projector body, if not perfectly balanced, swings rapidly through the range of its lower movement, and in the case of a large projector comes with a heavy bump against the fixed stops which limit such movement. Such rough usage is not conducive to the long life of the mirror (if of crystal glass) or other delicate parts of the optical apparatus.

Various suggestions have been put forward with regard to a "one wheel control" arrangement for projectors, that is, operating the movements of the barrel and turntable at one and the same time by one wheel. By means of suitable clutches either turntable or barrel can be operated separately, the advantages in support of this arrangement being the ease of manipulation with one hand wheel as against two, and that the operator always has one hand free to attend to the lamp, &c. Although there are these points in favour of such a device, the writer does not advocate their use, owing to the somewhat complicated clutch mechanisms employed.

Numerous improvements have recently been made in connection with switches and resistances: for projectors the latter should always be of the adjustable type and well ventilated, combined switches and resistances arranged in the projector base being among the more recent improvements.

Improvements in arc deflecting magnets, arc-centring gear, &c., are more or less of recent date.

Several very efficient types of portable generating sets are now on the market for use with field service projectors, or on ships where electrical equipment is not general. These usually consist of a gasolene engine and multipolar dynamo mounted on a light cast-iron bedplate.

Some approximate particulars of a double cylinder four-cycle engine and dynamo are: Capacity of 30 to 35amp. at 110 volts; weight, 650lb.; length, 42in.; width, 20in.; height, 30in.; revs. per minute, 750.

Fig. 5 shows a projector arranged for coast defence. It is controlled electrically from a distance, in such a way that the operator is remote from the beam of light, and also in the best position for observation. Projectors of this class are preferably provided with lamp carriages, to enable the substitution of a new lamp for one whose carbons are consumed to be carried out with the minimum of delay, so as not to interrupt the light more than necessary.

A characteristic type of Continental field service projector is shown in Fig. 6, mounted on its carriage. It is supplied with current from a generating set on another equally mobile carriage. The use of the metallic reflectors has permitted the construction of light and easily manipulated carriages for projectors up to 36in. diameter, which are extremely useful in hilly or mountainous countries.

THE POWER SUPPLY OF RIO DE JANEIRO.

The city of Rio de Janeiro, capital of the immense and rapidly developing Republic of Brazil, is destined to become one of the great trade centres of the world. Possessed of a magnificent natural harbour, it is the business centre of a country which is almost as large as the United States, and, so far as is known at present, uniformly fertile and productive in every direction. As a further natural advantage, and one which is a unique possession among the capital cities of the world, Rio de Janeiro has large water-power available in its vicinity. The electrical requirements of the city in the shape of lighting, power, and tramway services are now operated from this source. The transmission distance from the hydro-electric power plant to the city is about 51 miles, and current is transmitted by overhead mains across country at a pressure of 88,000 volts. The transmission circuits are carried on two steel-tower lines, each line carrying a duplicate set of mains. The conductors are of bare stranded copper with a hemp centre, the spans varying up to a maximum of 1935ft. The lines are side by side and are erected on a private right-of-way, about 100 yards wide, which the company has acquired for the entire route from the power house to the city. The country traversed is very rough in many parts, thick forest growths, granite boulders, and hills rendering the erection of the steel towers a work of considerable difficulty. The standard steel tower used has a height of 45ft. from the ground to the lower conductors; special towers were used of varying heights up to 60ft. On the straight work a span of 600ft. and a sag of 20ft. were adopted. The line insulators are of porcelain 19⅝in. high by 17½in. diameter. The capacity of each circuit at 88,000 volts, three-phase, fifty-periods, is 9000h.p.; thus each line has a full load capacity of 18,000h.p. The maintenance of the transmission line is in the hands of five patrol men; there are four patrol houses. The line is divided at switch towers into six sections. Tropical thunderstorms are of frequent occurrence, and the lightning arresters of the line are constantly in active service. The earth wire of the arrester system of the line insulators consists of ⅝in. galvanised steel cable, and although this appears to be sufficient on those parts of the

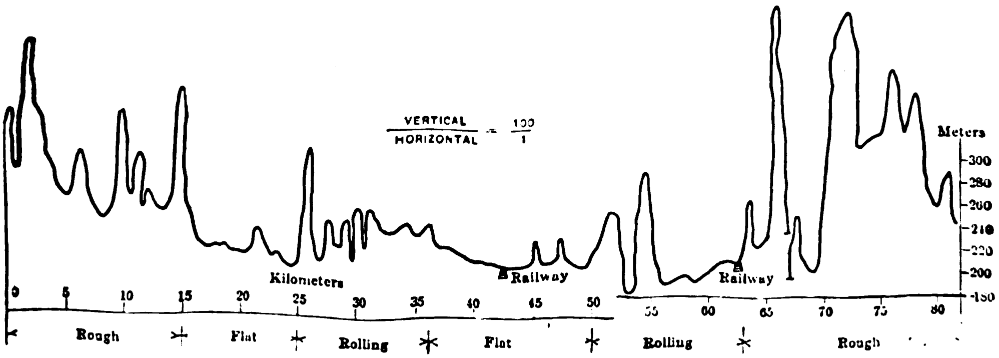


Fig. 1. Contour of Route of the Rio dr Janeiro Transmission.

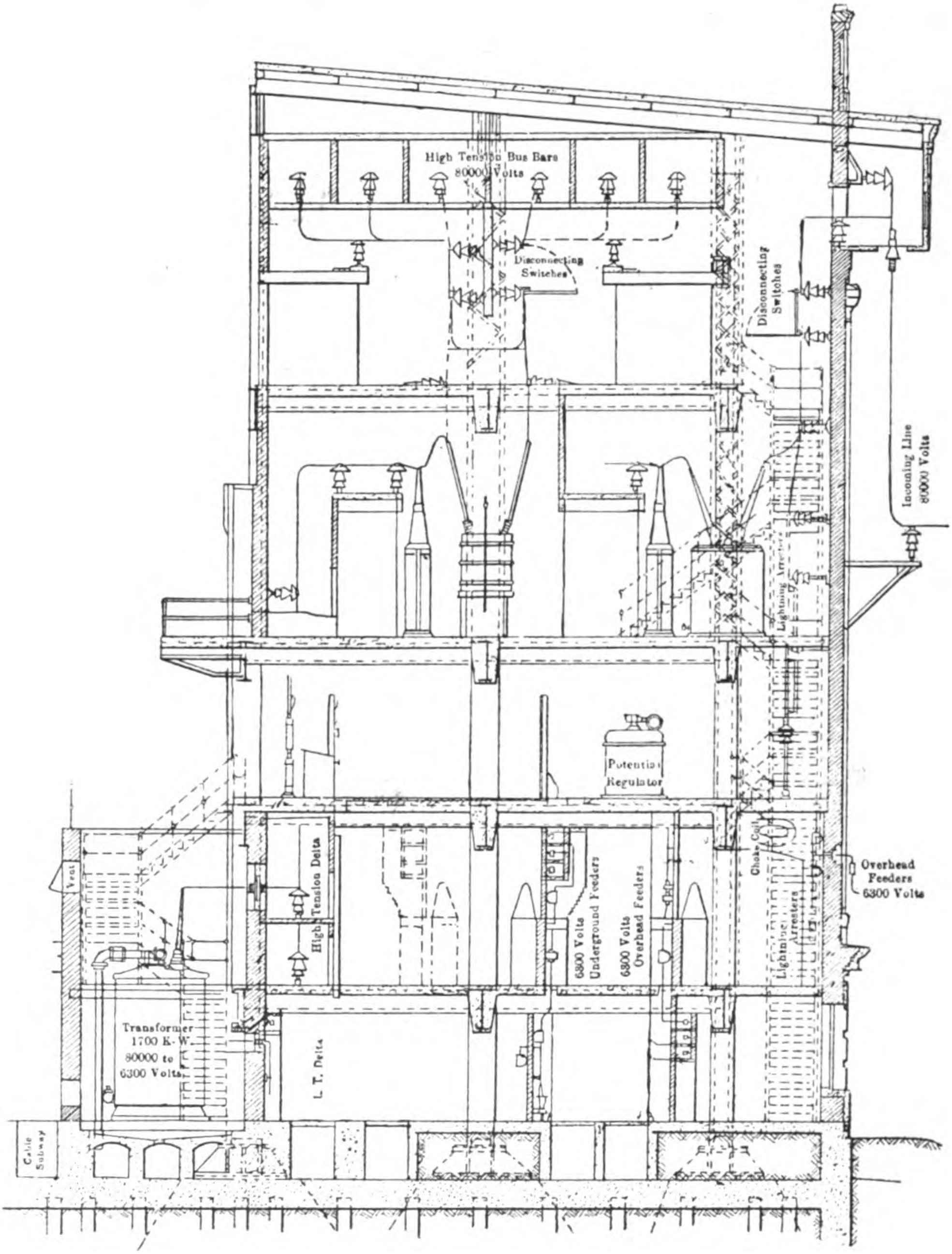

High Tension Bus Bars 80000 Volts
Disconnecting Switches
Disconnecting Switches
Incoming Line 80000 Volts
Lightning Arresters
Potential Regulator
Choke Coil
Overhead Feeders 6300 Volts
Lightning Arresters
6300 Volts Overhead Feeders
6300 Volts Underground Feeders
High Tension Delta
Vent
Transformer 1700 K-W. 80000 to 6300 Volts
L. T. Delta
Cable Subway

FIG. 2. SECTIONAL ELEVATION OF MAIN RECEIVING STATION.

line in hilly country, where the line is consequently shielded more or less from lightning discharges, there is not infrequent destruction of insulators by lightning discharge on those sections of the line which pass along the level low-lying country. There are, of course, full installations of lightning arresters at the city receiving station, and also at the power house ends of the lines. Two telephone lines are installed, one with branches to the patrol cabins for the use of the linesmen, the other, on a separate light pole line, being for through communication between the power house and the city terminus.

The receiving station in Rio de Janeiro is a steel-framed brick building situated about a mile from the centre of the city, and into which the high tension overhead lines enter direct. The building is about 240ft. long by 127ft. wide by 71ft. high. The general arrangement of the interior and the disposal of the plant are shown in Figs. 2 and 3. The step-down transformers consist of two groups, each group including two sets of ratio 80,000 volts to 6300 volts, and one set of 80,000 volts to 23,000 volts. The 6300 volt supply is for the general lighting and power service in the centre of the city, the 23,000 volt mains transmitting

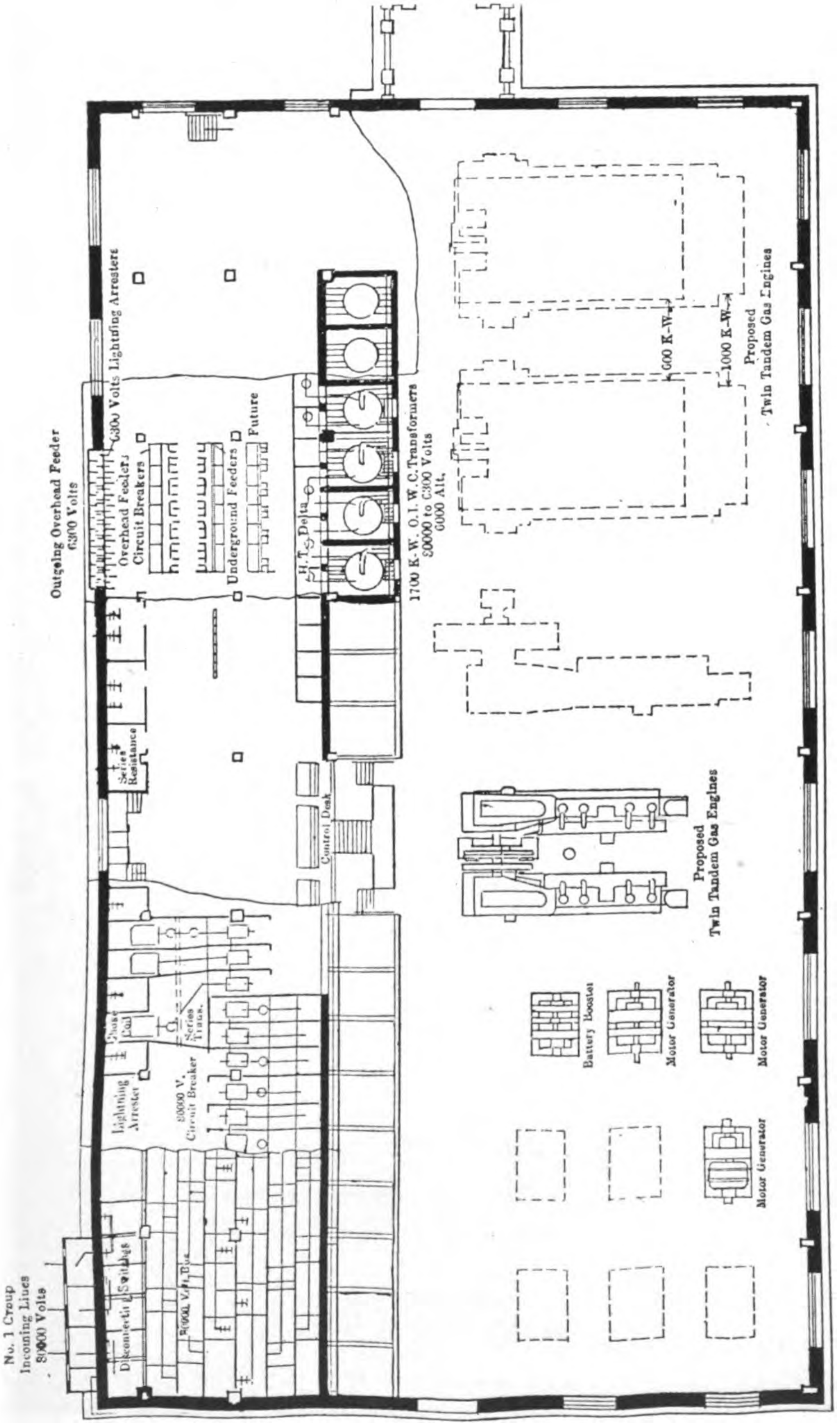

Outgoing Overhead Feeder 6300 Volts
6300 Volts Lightning Arresters
Overhead Feeder Circuit Breakers
Underground Feeders
Future
H.T. Delta
1700 K-W. O.I.W.C. Transformers 80000 to 6300 Volts 6000 Alt.
600 K-W
1000 K-W
Proposed Twin Tandem Gas Engines
Series Resistance
Control Desk
Proposed Twin Tandem Gas Engines
Choke Coil
Series Trans.
Lightning Arrester
80000 V. Circuit Breaker
Battery Booster
Motor Generator
Motor Generator
Motor Generator
80000 Volt Bus
Disconnecting Switches
No. 1 Group Incoming Lines 80000 Volts

FIG 3. PLAN OF MAIN RECEIVING STATION.

energy to the more distant suburbs. Each transformer is placed in a separate brick chamber or pocket, these being side by side, as shown in the plan Fig. 3, and covered by an overhead travelling crane for the ready removal or replacement of any transformer. The switchgear throughout is also arranged in brickwork cubicles, all bus bars being in duplicate and provided with section and cross-over switches, permitting the greatest flexibility between the primary supply circuits and the secondary distributing mains. The general arrangement of the primary and secondary switchgear is shown in the sectional elevation, Fig. 2. A gas-driven generating plant, supplied from the gas-lighting mains of the company and consisting of four 1000kw., 6300-volt, alternate-current sets, is to be installed at this main sub-station as an emergency and reserve supply, and provisions are made for the necessary bus bar interconnections. There are also installed five synchronous motor-generator sets each of 800kw.

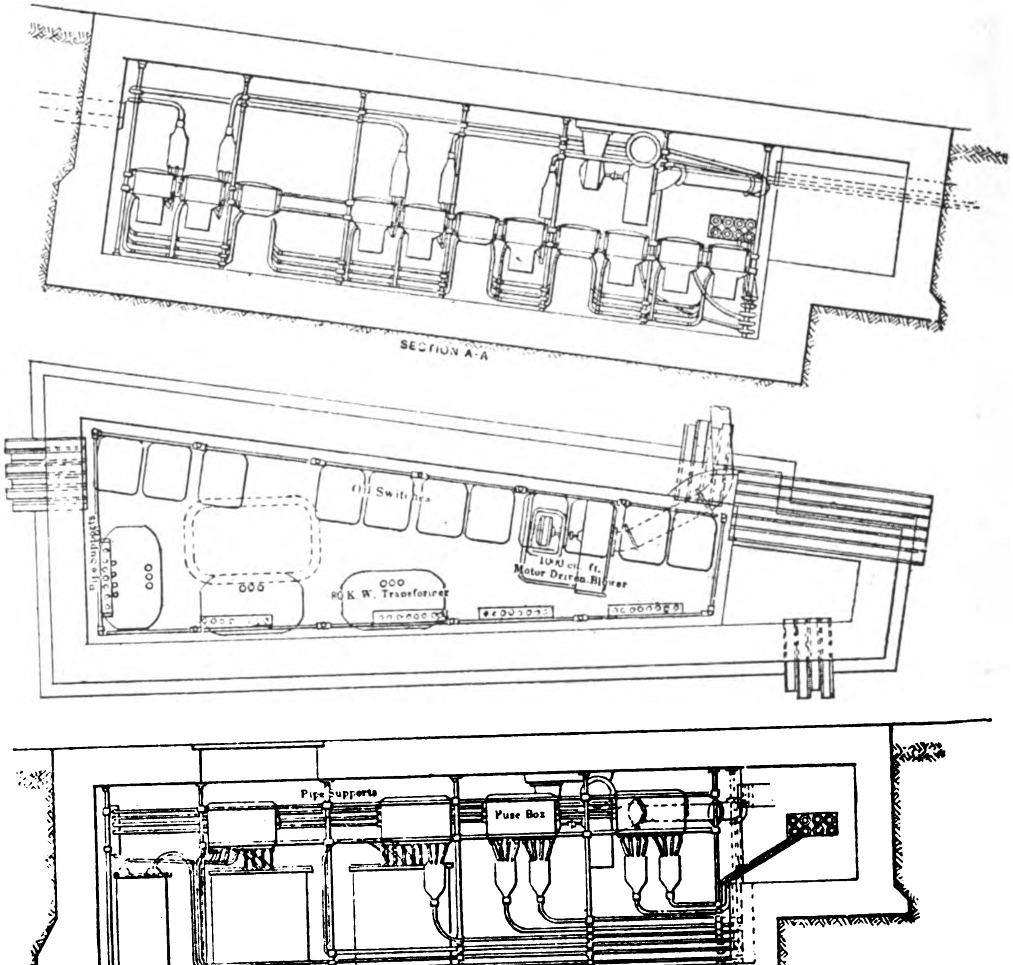
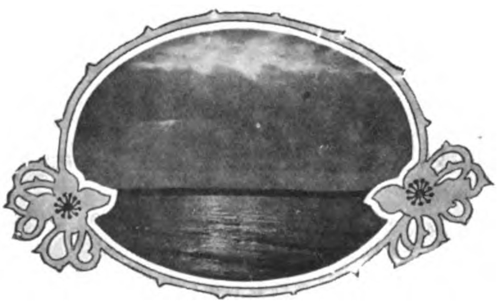


FIG. 4. A DISTRIBUTING SUB-STATION.

capacity, and yielding direct current at a pressure of 575 volts. Each of these sets consists of a 1200h.p. motor direct coupled to an interpole, compound-wound generator. They run at a speed of 500r.p.m., the synchronous motor being designed to run at a leading power factor of 60 per cent., and thus raising the power factor of the complete system. The direct-current side of the motor generators works in conjunction with a storage battery capable of giving 1000kw. discharge for one hour. There are also other motor-generators to be installed in sub-stations supplied from the 6300-volt mains and giving direct current for the more remote sections of the tramways.

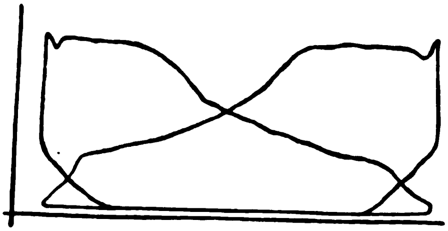
The distributing mains of the 6300-volt system are of lead-covered, paper-insulated cables. There are in all to be fifteen distributing centres or sub-stations, from which four-wire mains radiate to the consumers' premises, which are supplied at 208 volts across the outers for motors, and 120 volts between outers and neutral for lighting service. Transformers of 40kw. to 80kw. capacity are used in the sub-stations. All apparatus in these sub-stations, which are in the form of vaults below the street level, are of waterproof construction, owing to the risk of floods which occur during tropical rainstorms. The general arrangement of one of these sub-stations is shown in Fig. 4.

The entire installation has been very carefully planned to suit the existing conditions, and with a view to considerable extensions being readily carried out as future developments demand.

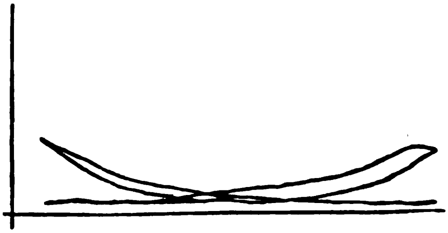


BALL AND ROLLER BEARINGS.

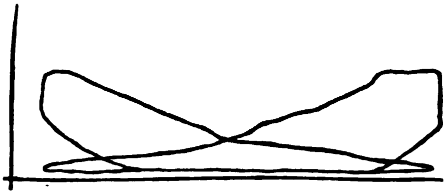
The question of friction losses in bearings has been so largely connected with problems of transmission of power that from time to time considerable prominence has been given to announcements that at last the perfect bearing, either of the roller or ball type, has been discovered. Extended experience showed in a good many cases that the report was inaccurate.



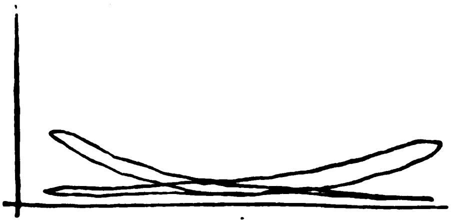
A—Engine Driving Complete Plant, 94h.p.



B—Engine running free, 4h.p.



C—Engine driving only Shafting with Plain Bearings, 40h.p.



D—Engine driving only Shafting with Ball Bearings, 6h.p.

Fig. 1.

Continuous progress has, however, been made towards perfecting these bearings, and it can now be said that reliable and cheap ball and roller bearings are on the market. There is, therefore, no reason why engineers should hang back any longer, and there really seems to be a pronounced inclination to adopt these bearings, and to get the benefit of the great economies to be derived from their use. In the electrical industry especially there is hardly any branch where their use will not be very beneficial.

They can be employed in generators, motors, rotary converters, tramcars, locomotives, motor-cars, wagons of all kinds, vertical spindle pumps, line shafting, and a host of minor machines. For use with motors they appeal especially to users, and also to electrical supply authorities which let out motors for hire, on account of their reliability and economy.

Advantages.

It can now be said that the possibility of breakdown is much further removed owing to the impossibility of a bearing seizing due to want of oil. Another important point in connection with dynamos and motors is the absence of wear on the bearing, and consequently the impossibility of the armature dropping and touching the pole pieces. Practical electricians will also appreciate the value of being spared the possibility of oil dropping on the commutator, windings, or floor, and the ease with which new bearings may be fitted, should any defect arise, is a great point in their

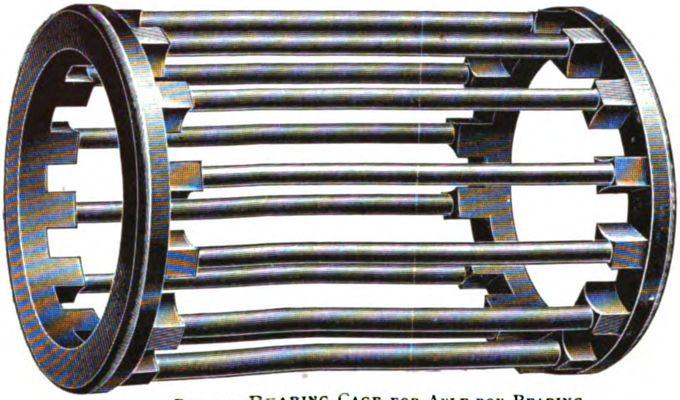


Fig. 2. Roller Bearing Cage for Axle-box Bearing.

favour. All these advantages have an effect on the cost owing to the saving in repairs, delays, oil and power loss in friction.

It should be noted that in connection with rotary converters the saving in friction effected by the use of such bearings is often of sufficient magnitude to involve the saving of the cost of a starting motor and its attendant complications, inasmuch as the machine is rendered self-starting. Moreover, due to the absence of wear on the hardened surfaces of the rollers or balls, the fear of the gradual wearing away of the bearings disappears, and the air gap can be reduced with a consequent great increase of electrical efficiency.

Another important sphere in which ball bearings are of extreme value is in the case of portable motors which may have to work in any position. It is difficult to lubricate these, and, unless they are fitted with ball bearings, they will probably give much trouble, owing to the fact that no ordinary bearing will contain the oil.

In connection with tramcars their use has been proved repeatedly to effect considerable economies. By means of tests of heavy vehicles the starting frictional resistance has been found to be reduced to 3lb. per ton of load and even less, including the wheel friction, on straight rails. Moreover, if roller bearings are fitted a saving may be made in the first expense in tramcar equipment by buying motors of about two-thirds the horse-power output that is required for cars equipped with ordinary bearings for maintaining the same schedule. The reduced starting effort is of great importance, and it not only saves power consumption, but also greatly reduces the rush of current through the motors at the moment of starting. This must of necessity lead to some economy in the maintenance of the motors.

Line Shafting.

The immense saving to be derived by putting factory line shafting on ball bearings can hardly be realised, or there would probably be no unconverted factory in the country. Fig. 1 shows the results of a series of tests, and from diagrams C and D

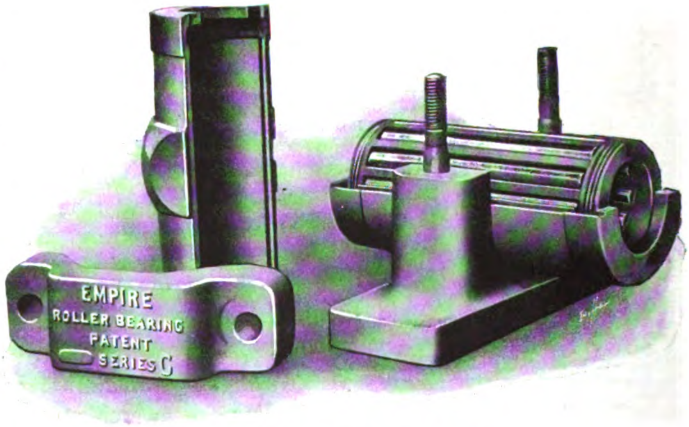


Fig. 3. Line-shaft Roller Bearing

it is seen that by substituting ball bearings for plain ones the horse-power required to drive the shafting alone was reduced from 40h.p. to 6h.p. As the total horse-power of the plant in question was 94, this is equivalent to a saving of over 36 per cent. If, when factories are being converted to electric driving, ball bearings were installed on all the line shafting that is permitted to remain, smaller motors might often be installed, and both capital and running costs would be appreciably reduced.

Tests on Tramcars.

Some very interesting gravity tests which are worth repeating were carried out some time ago on a tramway system. A tramcar weighing 2 tons 15 cwt. and fitted with ordinary bearings was let loose from a point 56ft. up an incline with 1ft. $6\frac{1}{4}$in. rise. It ran down the incline and along the level 57ft., making a total distance of 113ft. travel. The force expended in this way was 9364 foot lbs., the coefficient of friction was .0136, and the frictional resistance was 30.5lb. per ton. A similar car fitted with roller bearings ran a total distance of 376ft., and the frictional resistance worked out at 9lb. per ton, the coefficient of friction being reduced to .004. This showed a saving of 70 per cent. Trials were also made to test the relative starting efforts on gradients, with the following results, showing enormous savings :—

Starting Effort.

Gradient.	Car with Roller Bearings.	Car with Ordinary Bearings.
1 in 20	77	100
1 in 80	50	100
1 in 140	39.6	100

It is obvious from the above figures that cars will coast more easily if they are fitted with roller bearings, and will therefore effect great economies at the generating station.

Lubrication.

With regard to lubrication, the makers of ball and roller bearings seem to unite in recommending the following lubricants, and as they are presumably the

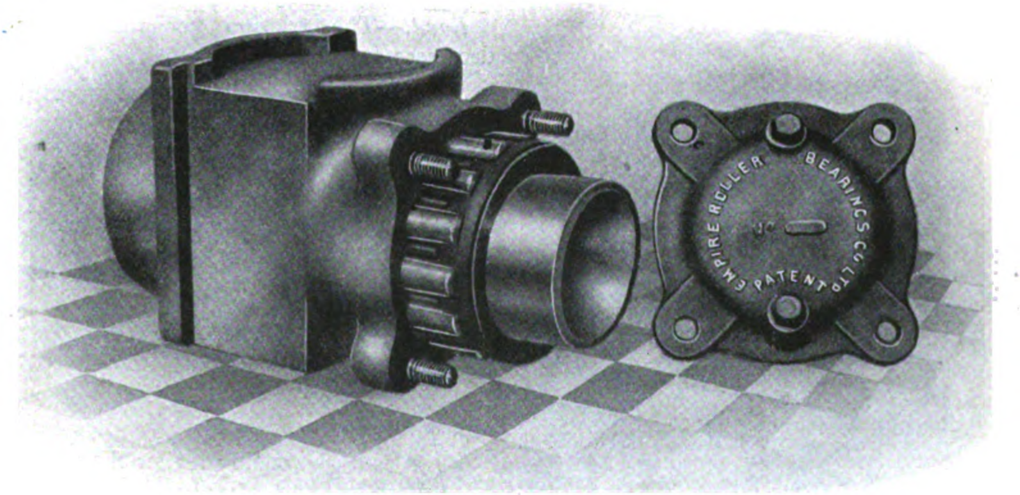


Fig 4. Roller Bearing Axle-box.

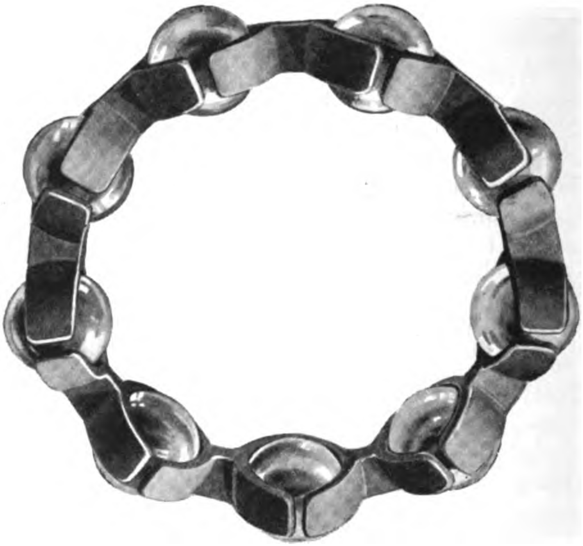


FIG. 6. BALL RACE OF D.W.F. BEARING.

persons most interested in maintaining their bearings in a good state, and as they have had the greatest experience in the selection of lubricants, their decision may be regarded as valuable. For electric motors thin oil is recommended; for general purposes with speeds over 600r.p.m. thin oil is also used. Between speeds of 600 and 100r.p.m. good cylinder oil appears to be the best lubricant, while under 100 revolutions grease is advisable. Graphite should never be used, even if mixed with oil or grease, as it is sure to abrade the polished surfaces of the balls, rollers, or races. An estimated figure derived from practice gives the amount of lubricant required for a good ball bearing as one-fifth of that necessary for a good ring bearing. One maker, the Standard Roller Bearing Company, specifically recommends the use of the Vacuum Oil Company's Gargoyle A cup grease No. 2.

Friction.

As regards friction, it may be taken as generally true that the coefficient of friction for good ball bearings or roller bearings is from one-fifth to one-tenth that of plain bearings, and is about .0011 to .0014. There is, or should be, no more friction in starting than in running. Professor Goodman, of the Yorkshire College, Leeds, made some very exhaustive tests on bearings made by the Empire Roller Bearing Company, and his results may be summarised thus:—

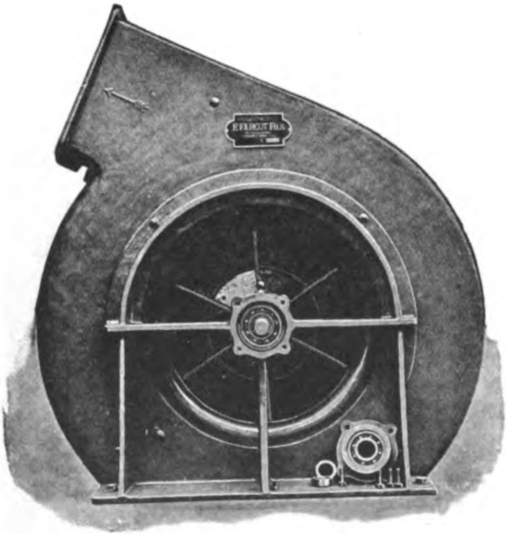


FIG. 5. MINE FAN WITH BALL BEARINGS.

Load.—The friction per ton of load decreases as the load increases.

Speed.—This has very little effect on the coefficient of friction.

Starting.—Starting friction is practically the same as running friction.

End Thrust.—If the bearings are properly constructed this is nil.

As regards the question of wear, users of ball and roller bearings declare that this is inappreciable, even after long periods of continuous use.

Types of Bearings.

In order to thoroughly review the present position of ball and roller bearings it is now necessary to give a description of various types of bearings suitable for use with general machinery, and the simplest way

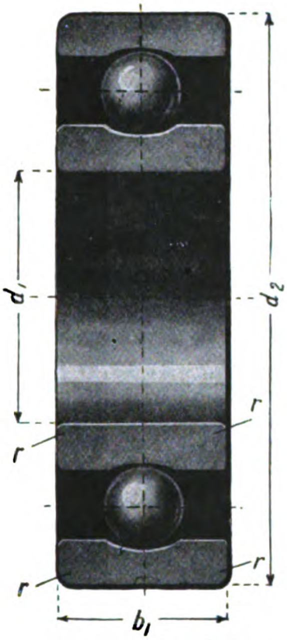


Fig. 7. Section of D.W.F. Bearing.

of dealing with the subject is to group these products under the various makers' names. The design of the Empire roller bearings is such that the load bearing parts have a true rolling movement on solid cylindrical rollers, all of which are controlled in alignment with the shaft by a special form of cage, which separates each roller, and thus prevents friction between adjacent roller surfaces which rotate in opposite directions. The patent cage of the type shown in Fig. 2 is very strongly made for railway and tramway axle-boxes, the parallel rods forming separate spaces to retain each of the rollers. Generally, the bearings run direct upon the naked shaft, except under conditions of exceptionally heavy loads for the given diameters, and also where the available length for the bearing is restricted, in which circumstances sleeves of steel, deeply hardened by a special process and ground, are used to protect the shaft, the rollers being of similar high-quality steel. By special process employed in the hardening, an extreme hardness to an ample depth of the outer surfaces is obtained, while still retaining internally the fibrous grain of best-quality mild steel, which obviates the fractures that are frequently experienced with cast steel water hardened. The bearings are made in various forms and sizes to suit all purposes, standard sizes being stocked for railway wagons, tramcars, motors, mine-tubs, and general engineering requirements. In all cases the bearings, as regards the size of rollers and quality of material, are proportioned to durably withstand the conditions of working, and types for line shafting purposes and trolleys and trucks are standardised to correspond with general millwrighting and railway practice. All bearings are self-oiling, owing to the complete revolution of the rollers around the shaft or axle. Fig. 4 shows a complete axle-box with the rollers, sleeve, and cage exposed. The universal swivel pattern bearing for line shafting, as in Fig. 3, is made divided throughout, so as to be easily fitted. Standard line shafting bearings are classified in three series—light, medium, and heavy. The first is for use at intermediate positions of line and countershafts; the second for posi-

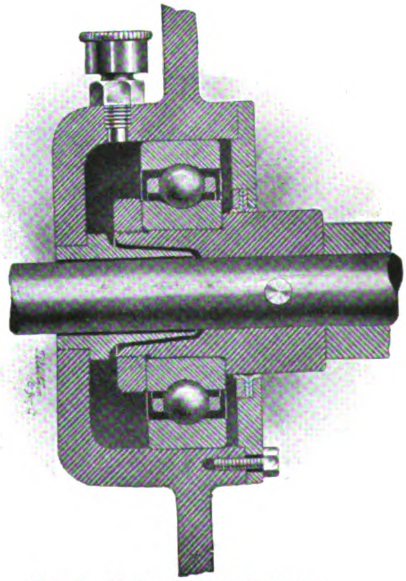


Fig. 8. Hoffman Ball Bearing.

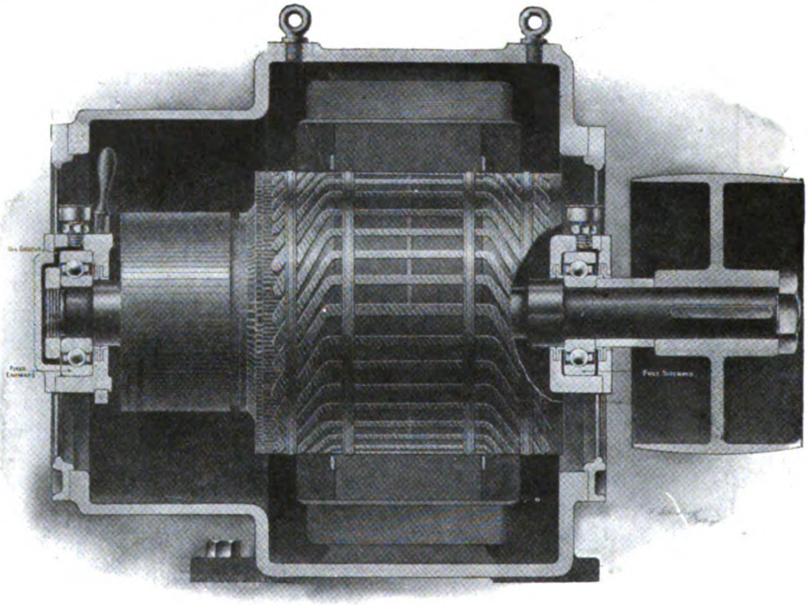


FIG. 9. MOTOR FITTED WITH BALL BEARINGS.

tions adjacent to main pulleys of line and countershafts and intermediate positions of main shafts; and the third for positions adjacent to main shaft pulleys. The Empire Roller Bearings Company, in addition to supplying bearings for ordinary transmission and haulage purposes, make a speciality of bearings for machinery where heavy loads or conditions of severe pressure have to be met. Under all such circumstances it is essential for bearings with solid rollers to be used of such quality and dimensions that no lamination of the load-bearing surfaces or elongation under load will take place. Upon calender rolls and similar machinery a reduction of total driving power amounting to as much as 40 per cent. has been found in practice to result. Bearings for roll necks up to 14in. diameter have been supplied by this Company to carry loads of 40 tons per bearing and 7in. diameter bearings for supporting tailings wheels carrying 25 tons on two bearings have also been supplied in connection with the South African gold mines with highly satisfactory results. The manufacturers claim the following economies:—10 per cent. coal costs on railways; 15 per cent. to 70 per cent. current cost on tramcars; 50 per cent. power cost on shaftings; and 50 per cent. to 75 per cent. lubricant costs.

These figures can be backed up

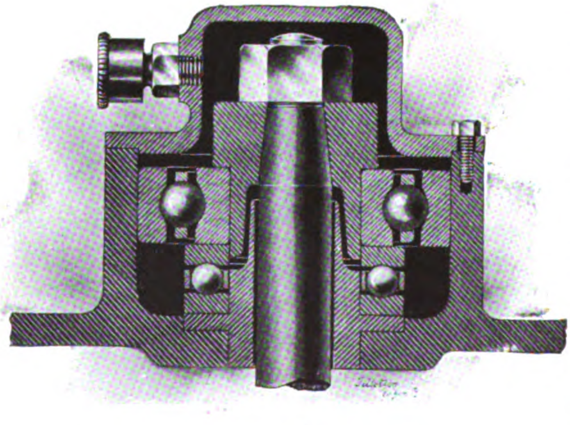


FIG. 10. VERTICAL SPINDLE MOTOR BALL BEARING.

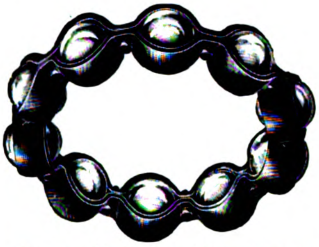


FIG. 11. OPEN-TYPE CAGE (TORMO).

by the following cases in which test figures were taken. On the track cleaning and watering car of the Wolverhampton Corporation Tramways a saving of current of 15 per cent. was obtained by the use of these bearings. On the Southport tramways a very careful test was made on one of twenty cars fitted with roller bearings; at ten miles per hour the mean current consumption over a given run was .797 unit per car mile with ordinary bearings, and .389 unit per car mile with roller bearings, giving a saving of .408 unit per car mile. As the estimated car miles per year amounted to about 400,000, the saving was 163,200 units, which at 2d. per unit represents a saving of £1560 per annum, or £68 per car per annum. Roller-thrust bearings with conical rollers are another feature of the Company's productions; they have been supplied for marine work and for general machinery purposes, and are further used in crane hooks for very heavy loads, bearings being in use for hooks supporting loads up to 100 tons.

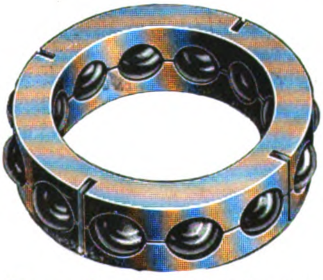


FIG. 12. SOLID-TYPE CAGE (TORMO).

A type of ball bearing which seems to be enjoying a well-merited reputation on the Continent is the D.W.F. bearing, manufactured by Messrs. Ludw. Loewe & Co., Ltd., and as instances of the reliability of this type the following facts are interesting. The Itala motor-car, driven across Asia by Prince Borghese, was fitted with these bearings throughout, and as they gave no trouble at all their performance is testimony to the excellence of design. The Marseilles Tramway Company some time ago fitted a 35h.p. motor running at 100r.p.m. with D.W.F. bearings, and after four years' continuous running, representing 64,000 miles travelled by the car without any adjustment or renewal of the bearings, these were examined and found in a good condition. The company then fitted twenty cars with similar bearings, and soon afterwards the Paris tramways followed suit by applying them to the cars under their management. In the Eisleben mines the flywheel regulator, which is driven by an electric motor at 500r.p.m., is fitted with ball bearings of the D.W.F. type. The flywheel weighs 15 tons, and has a peripheral speed of 310ft. per second. This is a very heavy duty for ball bearings, and the performance has been quite satisfactory.

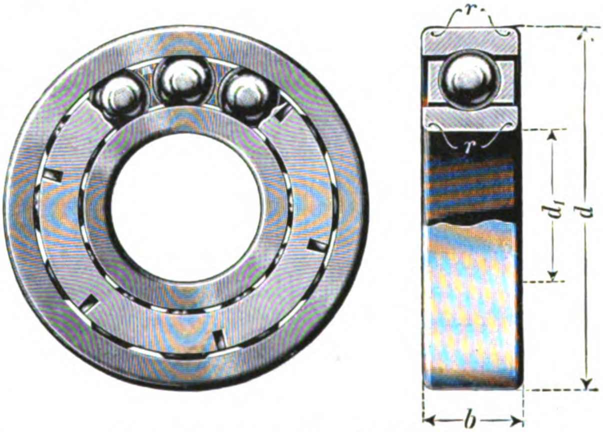


FIG. 13. COMPLETE TORMO BALL BEARING.

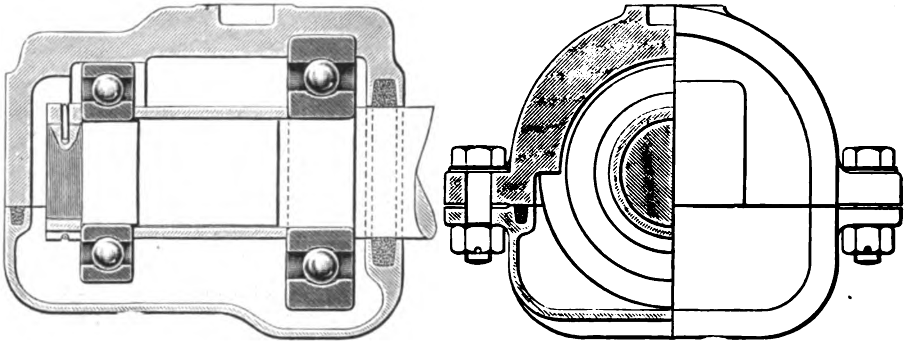


FIG. 14. CAR AXLE BALL BEARING.

Similar bearings have been used in generators and motors with armatures weighing up to 30 tons. At the Mounet et Moynes Mines a Farcot mine ventilator, driven by a 350h.p. motor, has been fitted with D.W.F. bearings. It is illustrated in Fig. 5, and it has run for two years without stopping. In England a large number of rotary converters are running on ball bearings of this type. The firm has four large factories—in Germany, England, France, and U.S.A. respectively—which shows that there is a considerable demand for bearings of this type. The principal feature of the D.W.F. bearing is the one piece ball cage, shown in Fig. 6. The races have no lateral grooves, screwed plugs, or other contrivances to enable the balls to be introduced, as is found in some other types of ball bearings, which means that not only are the races strong, inasmuch as grooves or flats must weaken them, but also that a perfectly uninterrupted surface is presented to the balls. The inner and outer rings, and the position of the balls secured in their cage, are illustrated in Fig. 7. Owing to their narrowness they save space, while they permit a certain latitude in alignment which would not be possible with plain bear-

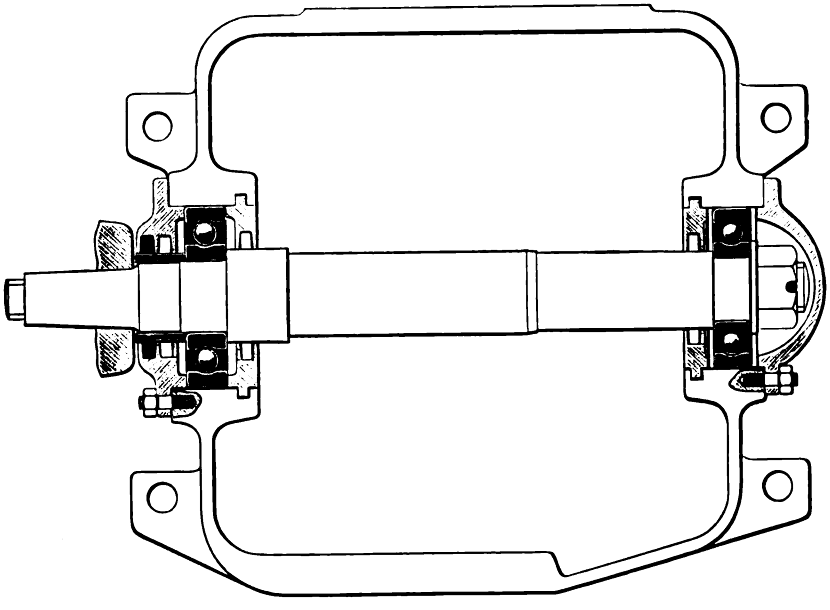


FIG. 15. MOTOR FITTED WITH BALL BEARINGS.

ings. They are also adaptable to vertical spindle motors. A special small type of ball bearing which is easily taken to pieces and reassembled is made by this firm for magnetos for motor-cars. The balls and races are made of Sheffield crucible cast steel. A bearing is put on to a shafting or axle by heating the inner ring or the whole bearing in oil to 104deg. Fah., and then driving it on with a few good strokes on the inner ring. If a generator is coupled direct to a steam turbine or a motor to a centrifugal pump, fan, or worm gear, the ball bearing on the armature shaft is relieved of end thrust by having a special thrust bearing, usually of standard design.

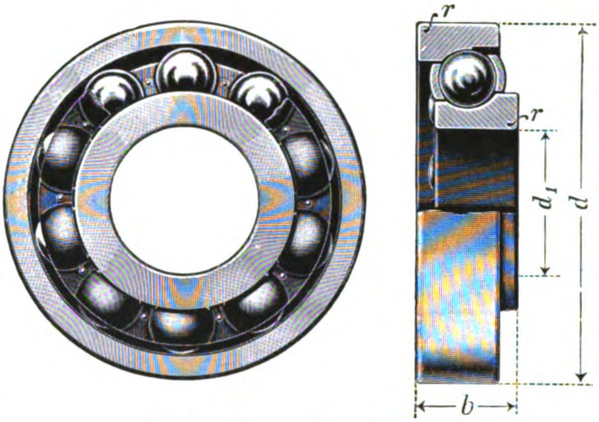


Fig. 16. Oblique Ball Bearing.

The Hoffman Manufacturing Co., Ltd., are well-known ball-bearing specialists, their journal bearings consisting of two hardened steel rings provided with curved ball races, and having a single row of balls held in a cage running between them. The number of balls is a maximum, the space between being just enough to ensure having a strong cage. It is not recommended that the races shall be entirely filled with balls, as at high speeds "inter-ball" friction injures the balls. Great care is taken to harden the rings uniformly, as upon this depends the lasting quality and success of the bearings. The balls are made of high carbon chrome tool steel, and are true spheres guaranteed to 1-10,000th of an inch. This ensures that the races are not overloaded at any point. The cage is made of gun-metal, this preventing undue wear should the bearings chance to become dry. It is made in halves and rivetted together. The ball races are accurately ground and polished, as grinding marks are found to wear the balls down. The bore of the inner ring and the outside diameter of the outer ring are ground accurately and true with the ball races, and the sides of both rings are also ground true, so that the whole bearing aligns properly when set against a collar on a shaft. The whole manufacture of these bearings appears to be very well and carefully carried out, the gauges used in the factory being tested periodically by Newall's measuring machines against standard rods, certified by the National Physical Laboratory.

To ensure that there is no continuous side or end thrust on the bearing when fitted, it is usual to clamp the inner race and to allow the outer to locate itself sideways. This plan is good enough for motors up to 10h.p., but for sizes over this it is usual to have double thrust washers which hold the shaft rigidly in place endwise, as shown in Fig. 8. The outer races of the journal bearing can then slide in their housing, so that they can locate themselves exactly opposite the inner ball races which are fixed to the shaft. Fig. 9 shows a direct-current motor fitted with ball bearings, and it will be seen that at the commutator end the bearing is fixed, while at the other end the outer ring is allowed to move endways in the journal. Fig. 10 shows this type of ball bearing adapted to a vertical spindle motor such as is used for pumps, ceiling fans, &c. The frame of the motor is brought up inside the bearings to make it oil-retaining, so that there is no difficulty in keeping the oil off the commutator and windings, and this constitutes the secret of success in this direction. In order to illustrate what has been done in the way of adapting these bearings to heavy electrical machinery, it may be mentioned that a rotary converter built by the Electrical Construction Company, of Wolverhampton, the weight of whose rotor was 20,000lb. and whose speed was 500r.p.m., is running well on Hoffman ball bearings, while a rotary converter built by the British Westinghouse Company, and whose rotor weighs 3400lb., runs at a speed of 600r.p.m on this type of ball bearing. The bearings have been made and successfully applied for loads up to 300,000lb. and for speeds up to 30,000r.p.m.

For cases where machines are subject to shocks and jars, special single-ball thrust bearings and double-ball thrust bearings are made, and for applications such as for gear spindles, &c., double compound ball bearings, consisting of four rows of balls, &c., each of the two outer taking the journal bearing load and the two inner the end thrust in either direction, are manufactured. Double-ball thrust bearings and washers are for use in taking the thrust in such cases as for a reversing worm gear, where the thrust alternates in direction, or where the load and pressure are intermittent and variable.

The Tormo Manufacturing Company are the agents in the United Kingdom for Messrs. Fitchel and Sachs, whose ball bearings are made at Schweinfurt, Bavaria. The firm started in 1895 with a few hands, and now employ over 2,000 in their extremely up-to-date factory. These ball bearings are in many respects like Hoffman's, but, by employing a patent cage, as much as 95 per cent. of the race is filled with balls. There are two types of cages—Figs. 11 and 12—the solid type, Fig. 12, being use for heavy loads, giving an excess of about 25 per cent. of safe load which can be borne by the size of bearing compared with the lighter type. The complete arrangement is shown in Fig. 13, while the arrangement for tramcar axle and motor is very well illustrated in Figs. 14 and 15 respectively. A very interesting variation of this type is shown in Fig. 16, which illustrates an oblique bearing for special purposes where a combination of rolling and end thrust is to be expected. All the usual varieties of ball-bearing arrangements are standardised, such as the double-row journal, double-row ball bearing for thrust pressure, double-thrust ball bearing with two sets of balls, &c.

(*To be continued.*)

THE WORLD'S PROGRESS IN ELECTRICAL AND GENERAL ENGINEERING.

Sulphur as a Cause of Corrosion in Steel.

MR. G. NEVILL HUNTLY, at a recent meeting of the Society of Chemical Industry, showed that sulphur is an important factor in the case of corrosion of steam boilers. This was brought to light by an investigation he made into the cause of pitting in a stand-by boiler. On examining the boiler numerous blisters were seen which were found to contain a liquid with a fine black powder in suspension. The liquid proved to consist of a solution of ferrous sulphate with a slight excess of sulphuric acid. The boiler water was always slightly alkaline. An increase in the caustic soda in the water had been tried without avail. The sulphur is present in the steel as manganese sulphide. The author points out that in a stand-by boiler the liquid has periods of rest, and the oxides deposit on the spot where they are formed, giving a coherent membrane. From the analysis of the scale it appears probable that the sulphur is first oxidised to free sulphuric acid, and this acid attacks the plate in its neighbourhood, the products being then precipitated by the alkali of the boiler water. Under these conditions this scale acts as a sort of semi-permeable membrane, admitting oxygen but not alkali, and thus giving rise to the anomalous effect of an acid corrosion going on inside a boiler containing alkaline water. The presence of streaks of sulphide in the steel thus gives a complete chemical explanation of pitting in the case of a stand-by boiler, and may also serve to explain the corrosion of steel plates along definite lines in experiments in which the liquid has not been kept agitated. It is of interest to note that the substitution of an alkaline arsenite for caustic soda in these boilers completely stopped the trouble.

◆

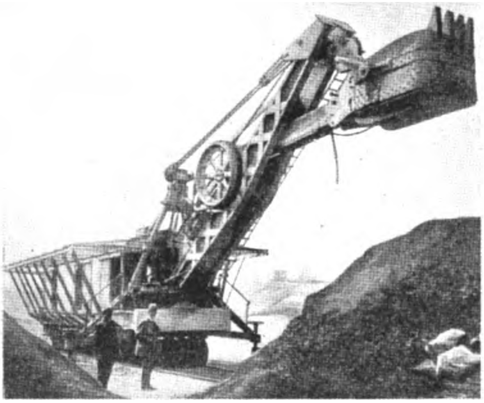
Electric Power Shovels.

WHAT are probably the largest electrically operated power shovels ever constructed, having buckets of four cubic yards capacity, have recently been placed in service at the limestone quarries of the Dolese & Shepard Company, of Chicago.

The hoist movement of these two 110-ton excavating machines is actuated by a 200h.p., 220-volt, series-wound, direct-current motor running at 415r.p.m.; the thrust motor, controlling the movement of the dipper handle, is an 80h.p. machine of similar type, while the swing boom is operated by an 80h.p. motor.

The motors for the hoist and swing-boom, or slewing, motions are mounted within the car. The thrust motor is placed out on the boom, communicating its motion to the bucket staff through reducing gearing connected to a pinion engaging a rack on the staff. The electric power supply to the shovel is completed through a feed cable, carried on a retractile reel on the shovel-cab, the return circuit being through the track rails on which the shovel advances. The shovel may also be fitted with a standard trolley for deriving power and for propulsion on ordinary electrified track.

Each of the motors is controlled independently by automatic, magnetic-switch controllers, which secure the greatest nicety of



Large Electric Power Shovel.

operation of the heavy bucket. This form of control protects the motors from any heavy overloads which may result from the bucket striking solid rock or other obstruction, by opening switches to introduce resistance into the motor circuit. The control panels and resistances are mounted in the rear of the cab, while the controller handles are conveniently placed under the hand of the operators.

Compared with the steam shovel, the electric-driven excavating apparatus has been found to present marked advantages of simplicity, economy, and ease of operation. The carting and handling of water and coal are avoided, fewer men are required to handle the machine, and a considerable saving of time is noted. For example, it is stated that the cost of operating an electric shovel of this type, but having a 75h.p. hoist, 30h.p. thrust, and 50h.p. swing-boom is 0.82d. per cubic yard of gravel, clay, and sand, while similar work performed by steam shovels would cost from 1.5d. to 2d. per cubic yard.

❧

Progress in Peru.

Although situated in the tropics the Republic of Peru, owing to its long seaboard and high altitudes, is remarkably well placed for colonisation and productiveness. The country has been at peace with its neighbours for ten years or more, and has developed its industries accordingly. The chief hindrance apparent in this development has been the lack of transport facilities, and much work is now being done and contemplated for improving the means of communication both by land and water. Certainly the most important of these schemes is the railway which is to connect the Peruvian port of Paita with the upper part of the Amazon River. This railway, for which a grant has been made by the Government, will be only about 400 miles long, but it will serve as the essential link in completing a trans-continental route. Its completion will bring Paita, on the Pacific, into direct connection with Para, at the mouth of the Amazon, on the Atlantic. It will serve to bring the valuable products of Brazil and the Amazon region to the West for the Pacific trade, and will form the outlet to the Atlantic and the East for the products of Peru and her neighbours, the great Amazon providing a freely navigable river up to the interior terminus of the new railway. Whilst the railway will be only 400 miles long, the entire distance of the trans-continental route will be about 3000 miles. From Paita the railway will ascend some 7000ft. in crossing the Andes, passing over the lowest part of this immense range of mountains. The new line will not only be of the greatest benefit to Peru, but it will be of vast importance as a highway for the world's traffic.

Communications by water are being improved by the building of steamers, docks, and ports. A new company has been formed to acquire and operate a fleet of coastal steamers. This company has also placed an order with an English firm for a large floating dry-dock, the dock to be capable of lifting a 7000 ton vessel in two hours. The port of Callao is being developed, and, altogether, there is a considerable field open for manufacturers of machine tools and general shipyard and dock appliances.

The Chimbote Coal and Harbour Syndicate has practically completed the first section of its railway which opens up the coal-fields. The coal deposits have proved to be ample and good, and large quantities of anthracite and bituminous coal are now being got. Considering that hitherto Peru has been importing all her coal, the importance of this opening up of a new mining area is apparent. In the same district there are profitable deposits of gold, silver, and copper awaiting the completion of the railway for their development. Mining plant and appliances are in constant demand, and British manufacturers of such machinery and specialities should see to it that they keep their names and goods well to the fore. In the way of minerals there should also be mentioned the fact that petroleum is being got, and that there is a field open for the makers of oil refining plants.

It is not necessary to do more than indicate the productiveness of the country as an agricultural and stock-raising centre. Owing to its situation and the extreme altitudes, it can be said that Peru possesses all climates from the torrid to the frigid. Cattle and sheep thrive on the uplands, and fruits and crops as we know them are the order; lower down tropical fruits and produce are obtained. In all cases the land is fruitful and conducive to settlement and industrial prosperity, which means a rapid growth of population, and much work for all classes of engineers.

❧

A 5,000 K.W. Exhaust Steam Turbo-Generator.

THE famous power house of the Rapid Transit Company, of New York, has recently added to its capacity by putting into commission the first of a series of low-pressure turbo-alternators. The present high-pressure steam unit equipment consists of nine of the curious Allis-Chalmers double-horizontal and vertical compound engines, each rated at 7500i.h.p. capacity, and three horizontal turbines of the Parsons type, each of 1250kw. output. It is in connection with one of the nine reciprocating engine sets that the first 5000kw. exhaust steam turbine has been installed. Considering that the subject of exhaust steam power generation is one of the foremost in engineering circles in this country, some particulars of this installation will be of interest. The reciprocating set consists of two high-pressure horizontal cylinders, 42in. diameter by 60in. stroke, and two low-pressure vertical cylinders, 86in. in diameter by 60in. stroke. Both pistons of each side of the engine are connected to one crank-pin. The speed of the engine is 75r.p.m., and the pressure at the stop-valve is from 175lb. to 200lb. per square inch. The receiver is not steam-jacketed; the high-pressure valves are of the poppet type for use with super-heated steam; the low-pressure cylinders are fitted with the usual Corliss valves. The alternator has a rating of 5000kw., three-phase, 25-periods, 11,000 volts. Originally the engine was equipped with two Alberger jet condensers with barometric column discharge, two hot wells, one dry vacuum pump, and one cross-compound circulating pump.

The use of the low-pressure exhaust steam turbine has, of course, meant the disuse of the jet condenser plant and alterations in the exhaust piping arrangements. The low-pressure cylinders now exhaust direct into the turbine, an oil separator being interposed between. The turbine is of the Curtis vertical type, and exhausts into a surface condenser over which it is placed, the condensation water being free from oil and suitable for boiler feed use. The turbine is direct-connected to an induction generator rated at 5000kw., three-phase, 25-periods, 11,000 volts, which is electrically connected with the alternator of the main reciprocating set without the intervention of switchgear of any kind. Thus the turbine requires to have no speed regulator or governor, it being regulated by the turbo-generator, which is controlled by the main alternator of the reciprocating set; the speed control of the two combined units depends therefore upon the engine governors. Details of close tests as to the performance of the complete reciprocating-turbo combination are not yet available, but it is stated that the turbine consumes 15lb. per kw. hour when supplied with steam at 12lb. to 17lb. absolute pressure and with an exhaust vacuum of 28in.

So far the significant results of this particular installation have reference to first cost. The putting down of this exhaust steam set has doubled the capacity of one of the original generating units at a cost of less than one-third that of the original reciprocating plant. Moreover, this increase has been accommodated without adding to the size of the building in any way—a most important feature when it is remembered that the land and buildings of this particular power house represent the largest item in the original capital expense. It is also important to note that the condensed steam of the turbine discharge is good for feed-water, whilst hitherto all water for this purpose has been drawn from the public mains, and, being paid for by meter, has been a very costly item in the works accounts.

⁂

Electrification of Canadian Grand Trunk Railway.

HITHERTO the proposals to electrify main lines of railroad in Canada have been limited chiefly to the Western sections of the Dominion, where large water-powers are abundant. It is reported that the electrification of the Grand Trunk Pacific Railway from the St. Lawrence River to Moncton is now under serious consideration by the railway company, the Dominion Government, and the New Brunswick Cabinet. Electrical engineers who have given the subject consideration declare the conditions to be entirely favourable. The distance between the St. Lawrence and Moncton is about 460 miles, and for a considerable part of the distance the road passes through dense forests of spruce and fir in lower Quebec and northern New Brunswick, as well as through the rich farming country along the upper St. John Valley. What has given impulse to the new plan is that at Grand Falls on the St. John River, 170 miles from the St. Lawrence and 160 miles from Moncton, there is water-power sufficient to develop energy enough for the working of the whole road. At this point the river has a natural fall of about 130ft., and a flow that will be sufficient to furnish from 100,000 to 125,000h.p. continuously by the utilisation of comparatively inexpensive means of storage and conservation. As the requirements of this section of the railway are estimated at not more than 40,000h.p., there is every reason to believe that the supply will be more than equal to the needs.

⁂

The Coal and Iron Industry in Germany.

VERY complete statistics of the coal and iron trades in Germany for the first half-year of 1908 and 1909 are published in a recent number of *Glückauf.* We give below some of the principal figures :—

Coal Trade.—Home production.

Totals for the whole German Empire, January to June :—

Half-Year.	Coal.	Lignite.	Coke.	Coal Briquettes.	Lignite Briquettes
	Tons.	Tons.	Tons.	Tons.	Tons.
1908	72,695,452	32,047,323	10,612,410	1,959,995	6,805,213
1909	71,905,114	32,422,221	10,368,742	1,838,447	7,062,820

Coal and coke imported from Great Britain in January to June :—

Year.	Coal.	Coke.
1908	4,768,735	24,105
1909	4,649,861	32,512

Total imports of coal and coke from other countries, excluding Great Britain :—

Half-year.	Coal.	Coke.
1908	790,619	234,108
1909	780,435	292,332

Exports, principally to European countries :—

Half-year.	Coal.	Coke.	Lignite.	Lignite Coke.	Briquettes. Coal.	Briquettes. Lignite.
1908	9,838,175	1,811,871	13,328	771	607,893	194,570
1909	10,320,519	1,592,281	15,634	1022	538,016	220,498

Of the exports the chief buyers of German coal are Austria, Holland, Belgium, and France, which countries in all took over 8¼ million tons, Austria alone taking over four million tons.

Of the imports of coke Belgium supplied by far the greater portion, viz., about 200,000 tons.

Metals.—Iron ore (various), January to June :—

Half-year.	Imports. Tons.	Exports. Tons.
1908	3,320,683	1,675,128
1909	3,766,827	1,323,680

The other ores, such as lead, chrome, nickel, sulphur, gold, silver, wolfram, zinc, tin, slags, &c., are represented almost entirely on the import side, the exports being unimportant.

Totals for ores of all kinds :—

Half-year.	Imports. Tons.	Exports. Tons.
1908	4,284,410	1,750 577
1909	4,681,546	1,388,637

Iron.—Total imports and exports :—

Half-year.	Imports. Tons.	Exports. Tons.
1908	284,517	1,825,749
1909	211,727	1,872,568

Of the imports the chief feature is pig iron for foundry work, 126,055 tons being taken in 1908 and 68,039 tons in 1909 (first half-year). The exports in the same class of material were 113,943 tons in 1908 and 195,544 tons in 1909.

The imports in rails and rolled sections are unimportant, while the exports come to about 1,400,000 tons. Details are not given as to where these exports went to.

On the whole, the figures for the two first halves of 1908 and 1909 show very little difference both as regards home production of coal and as regards the imports and exports. If anything is indicated at all it is a slight decline in trade in 1909, to judge by the fact that nearly one million tons less coal was used from January to June than during the same period of 1908. In the ores imports have risen slightly and exports have dropped, but no comparative figures are as yet available for the home production, so that much attention must not be given to these figures as far as an indication of the state of the industry is concerned.

In a later number of *Glückauf* is an article on the iron industry of 1908 in which figures are given showing the falling off owing to bad trade. Thus the total production of raw iron in all countries was 12½ million tons less in 1908 than in 1907, or a reduction of 20¼ per cent. The figures for the three principal iron producing countries are :—

	1907	1908	Reduction.
U.S.A. .. .	26,193,863	16,190,994	38·6
Germany	13,045,760	11,813,511	9·4
Great Britain ..	10,082,638	9,438,477	6·4%

Further figures show that the above three countries use more iron than they produce, and that Spain and Sweden supply the greater part of the necessary ore. In 1907 these two countries produced 13 million tons of ore which was exported. The world's production of pig iron for 1907 was 51 million tons, which is a record figure, and the amount for 1908 will undoubtedly fall very short of that. Figures for steel production are given for 1908, viz.: Steel of all kinds:—

U.S.A.	14,119,989	tons.
Germany	11,186,379	,,
Great Britain	5,380,373	,,
France	2,727,617	,,
Canada	598,183	,,
Sweden	347,600	,,

In Germany 19,536 tons of steel were made in the electric furnace; in France 2,289 tons.

* * *

The St. Clair Tunnel Electric Railway Results.

In September of last year we published an illustrated description of the electrical installation at the St. Clair tunnel. The system has now been in operation a sufficient length of time to enable comparisons to be drawn by actual experience as to the relative advantages and economy of electricity and steam in the working of the tunnel. The following details from a Canadian correspondent of The Electrical Magazine and Engineering Monthly will be found of interest and value.

Electrification has increased the capacity of the tunnel; it has reduced operating expenses; and it has removed a serious handicap from the passenger traffic. These improvements are the direct result of the use of the single-phase locomotive. The electric locomotives draw 1000-ton trains up the 2 per cent. gradients at 10 miles an hour, while the steam locomotives were barely able to draw 700-ton trains at the rate of 3 miles an hour. Under electric conditions the average time of the journey from summit to summit is ten minutes, and the average number of cars per train 27.3. Under steam conditions the average time was fifteen minutes, and the average number of cars 19.7. During the first twenty-four hours of continuous electrical service 1529 freight cars, besides the regular passenger trains, were passed through the tunnel; the record under steam operation (exclusive of a special test under extraordinary circumstances) was 1501 freight cars and the regular passenger trains. For several years the business, during the season when lake and river navigation was closed, at times exceeded the capacity of the tunnel. With the electric service the capacity of the tunnel exceeds the capacity of the terminals. An estimate, allowing a fair proportion of the cars passing through to be freight, shows the capacity of the tunnel under electric operation to be 30 per cent. greater than it was under steam.

The electric locomotives have performed the entire tunnel service since 17th May, 1908. Previous to that date there were two months of eighteen hours per day electric service, and at an earlier period some experimental electric operation. The transition period covered about ten weeks, continuous electric service not being inaugurated till the men and the system were thoroughly broken in. The change was made with practically no interference to traffic, and the new service has been a success from its very beginning. Each of the five electric locomotives originally installed has made about 30,000 miles, and the wear on the gears is inappreciable. During the first six months there were only thirty-four interruptions to traffic, nine of which were due to the electric locomotive. On one occasion the trolley-wire was burned through by the careless resetting of the pantagraph of a work train locomotive. On another occasion a box car with an extraordinarily high hand brake wheel grounded the tunnel trolley, but the trolley breakers cleared the trouble, and no damage to construction resulted. The worst interruption since the change of system occurred on 17th Aug., 1909, when a freight train broke in two while going up the grade on the Michigan side. Twenty cars ran backward into the tunnel, and one of them, having jumped the track, derailed the others and caused a bad wreck, which held up traffic for nearly ten hours. The electric current was immediately shut off, and the work of clearing the wreck proceeded without any danger to the men employed. This accident was not due to any defect in the electrical installation.

The electric locomotives have completely transformed the atmospheric conditions of the tunnel. The air is now free from smoke, gas, and steam, and the tunnel is as clean and well lighted as a city street. Air brakes can be used on all the trains, which could not be done with safety under steam operation, for reasons explained in the former article. Fortunately no accident occurred to a passenger train during the eighteen years of steam service, but there were accidents to freight trains which caused loss of life and gave the tunnel a bad reputation. With the use of air brakes greater speed is allowable and therefore increased capacity. The elimination of exhaust steam and corrosive fumes has removed a cause of depreciation to passenger rolling stock, and the lighter electric locomotives are less severe on the rails and road bed than the heavy steam locomotives.

In the matter of fuel the electric service shows great economy. The coal bill for the locomotives during the last six months of steam service averaged $4956 per month, and for the first six months of electric service only $1152.60 per month. Hard coal costing $6 a ton was used on the steam locomotives; bituminous coal costing $2 a ton is now used in the power station. The maintenance of the steam locomotives averaged 13.6 cents per locomotive mile; for the electric locomotives it averages 4.3 cents per locomotive mile. There has been 15 per cent. reduction in the total wages paid to locomotive crews, and 23 per cent. in the total wages paid to train crews. The first six months of electric operation showed 44 per cent. reduction on the cost of steam operation.

The power consumption for the passenger service averages about 38 watt hours per ton mile, and for the freight service about 35 watt hours per ton mile.

In every respect therefore the electric installation at the St. Clair tunnel has resulted in increased efficiency and economy.

❧

Flexible Couplings. THE flexible couplings made by the Power Plant Company have several points which render them peculiarly suitable for electric motor service: they are balanced, reversible and insulating. The several illustrations indicate the general construction of the standard form of these couplings. Reference to Figs. 3 and 4 show that the coupling consists essentially of three parts. One half, *a*, of the coupling is made in one piece and carries the projections *d*, which engage with corresponding projections *e* in the other half. The latter half is made up in two parts—the boss *b* and the shell or rim *c*, these two being bolted together as shown to form a complete half-coupling. This division facilitates erection, allowing of the shaft-ends being

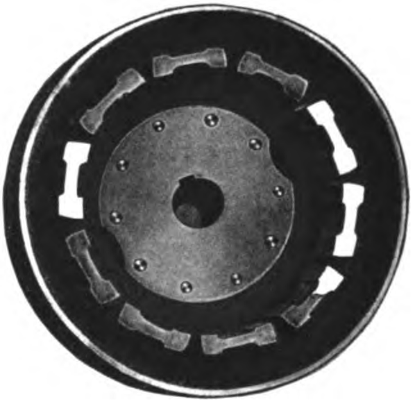


FIG. 1.

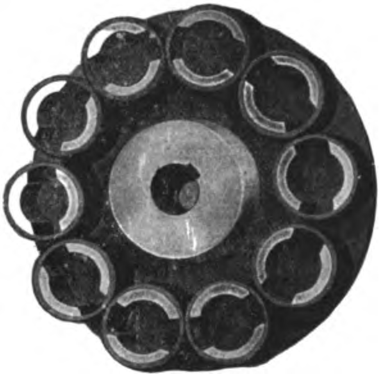


Fig. 2.

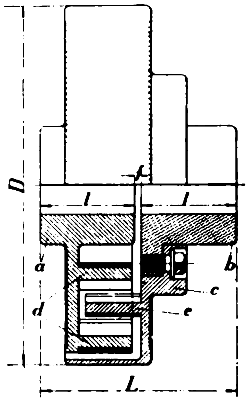


Fig. 4.

fitted, and the two halves of the coupling keyed on before setting the shafts in line. The corresponding projections *d* and *e* of the two halves are connected by strong leather rings which take the driving force. These rings ensure great strength and flexibility; they are insulating, and permit of reverse running without shock or jar. According to the size and speed of the coupling the number of rings used varies from six to twenty-four in the standard types. The makers state that each ring is in itself strong enough to transmit the whole rated power of the coupling, and consequently there is practically no possibility of breakdown should one of the rings fail during service. The coupling is neat and compact, the outside of the part *c* being highly polished and, overhanging the other half, makes the whole dust-proof and free from projections. The plain polished flange of the standard coupling can be replaced by pulley, gear-wheel, fly-wheel, &c., as desired. The couplings are also made in combination with claw and friction clutches, and in this they provide the self-contained and light, well-balanced gear which is very frequently sought for by those who have electric motors to adapt to machine driving.

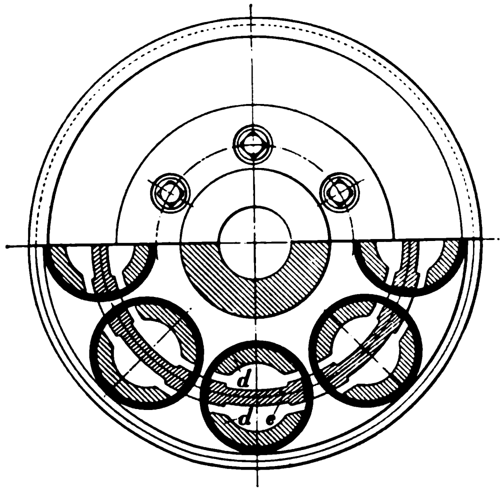


Fig. 3.

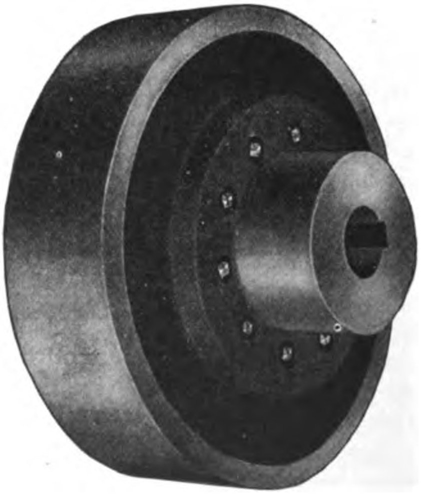


Fig. 5.

Induction Steel Furnaces in the States.

THE American Electric Furnace Company has installed an experimental plant under the patents of Kjellin, Colby, &c., at Niagara. The installation comprises one 10-12kw., one 40-60kw., and one 100-150kw. furnace. These furnaces are of the Kjellin type, and are fed by a transformer with a tapped secondary winding, allowing the pressure at the furnaces to be regulated between 475 volts and 600 volts. The results have been very satisfactory, and show a considerable economy in production and labour. For refining work the consumption averages 600kw. hours per ton of finished steel.

❧

The Steam Collier "Pallion."

A NEW form of coaling steamer is described in a recent number of *Engineering*. This vessel, the *Pallion*, is equipped with twin belt conveyors which discharge the whole of her cargo. The belts travel the full length of the boat in a space underneath the cargo, carrying the latter aft, and transferring it on to a return belt, which again passes it on to the delivery belts, which are carried in swivelling booms. These booms can be raised and lowered and can swing, so that the cargo may be delivered into railway trucks or bunkers on the quay-sides or into barges alongside the ship. A set of compound engines drive the conveyor gear, which is capable of discharging 500 tons of coal per hour. The holds are arranged with thirty vertical slide doors, which are operated from the centre tunnel, and are so arranged that 75 per cent. of the cargo falls on the conveyor by gravity. Special openings are provided at the bottom of the hold for clearing the remainder of the cargo, which is worked out by hand, assisted by the outwardly-sloping floors of the hold. The builders state that the total cost of discharging the cargo will not exceed £12, including upkeep of gear, while, for instance, the present cost of discharging the same cargo at Hamburg would be, roughly, £112, about 110 men being employed on the work, which would take at least eleven hours. The *Pallion* will discharge her cargo in from six to eight hours, and will employ six to eight men for part of the time only, viz., for clearing out the last part of the cargo. Besides the reduction of cost, it has been found that with the conveyor method there is less breakage of the coal. In the poop are two Denison automatic weighing baulks which record the weight of the cargo as it is carried over the machines. The *Pallion* was built and engined by Messrs. William Doxford and Sons, Sunderland.

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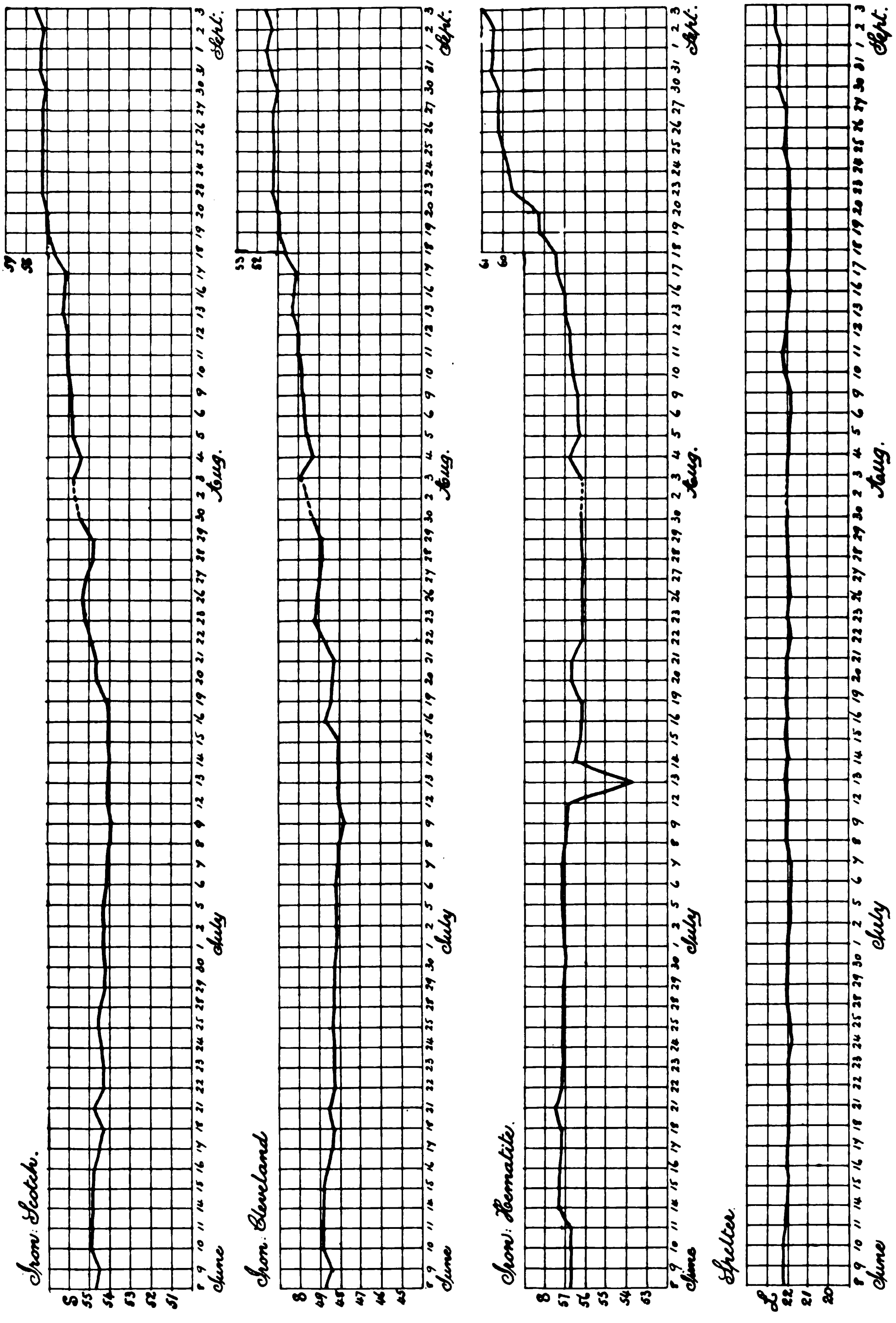
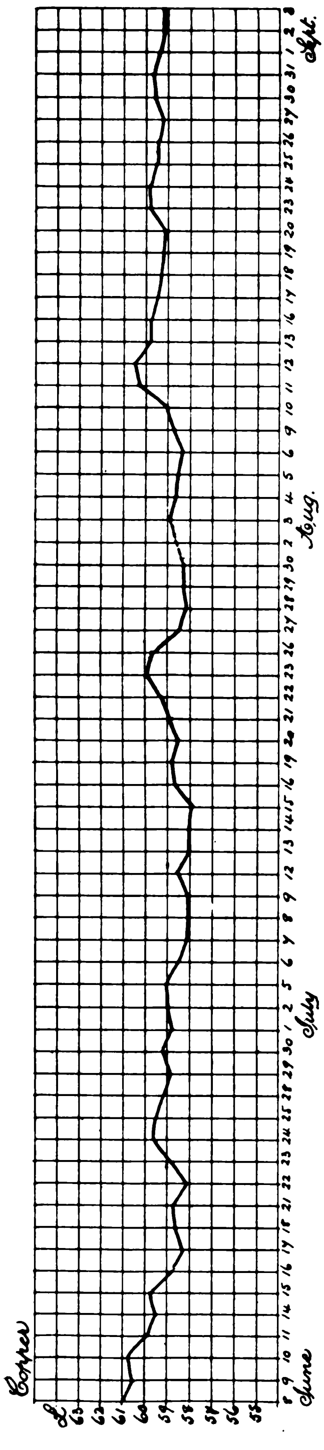
Exhibition at Buenos-Aires.

FROM May to November next year (1910) there will be opened at Buenos Aires a grand international exhibition of railways and of all other kinds of land transport and allied industries. The year 1910 will be the hundredth anniversary of Argentine Independence. This immensely fertile territory offers a great field for industrial enterprise, both in relation to agriculture and to mining work, and our manufacturers should not miss this opportunity of increasing their share in the business to be obtained. The Argentine Republic covers an area of three million square kilometres. In 1908 the exports exceeded the imports by about £24,000,000 sterling, and there is little doubt that every year will continue to show a substantial increase on this figure. The country is developing at a great rate; already there are about 17,000 miles of railway constructed, and at the present rate of progress it is not too much to say that in another twenty-five years this figure will be quadrupled. The forthcoming exhibition is being taken up in a whole-hearted manner by our American cousins, who are keenly alive to the great possibilities which the Argentine and the neighbouring South American republics offer for engineering trade expansion.

Home Market Metal Prices for the Past Three Months.

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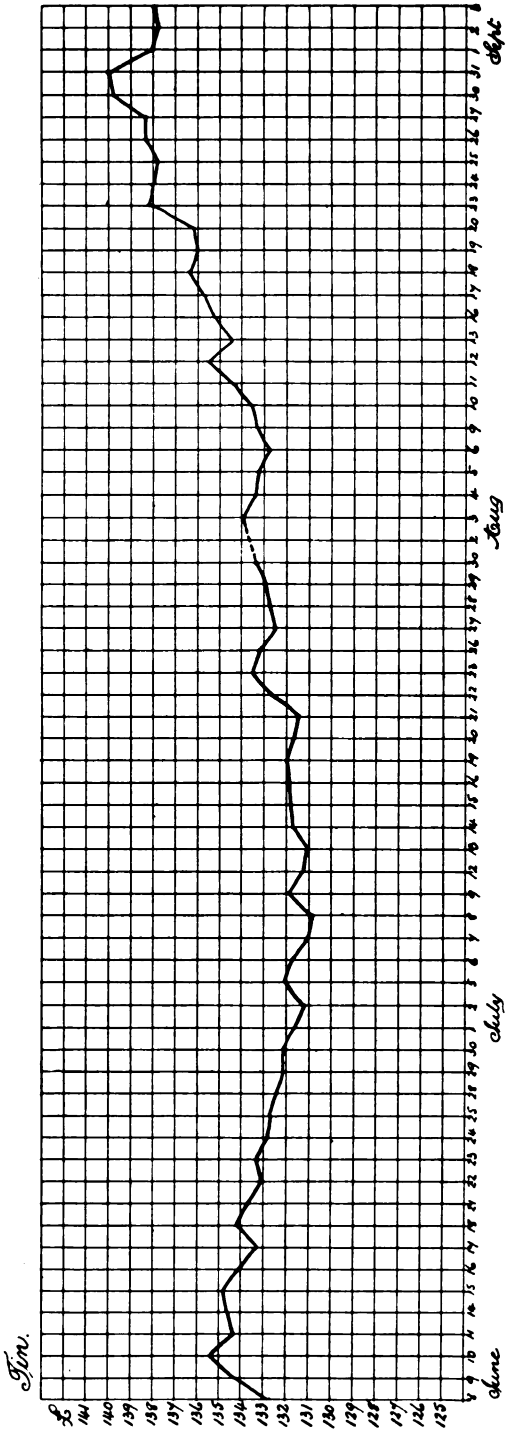
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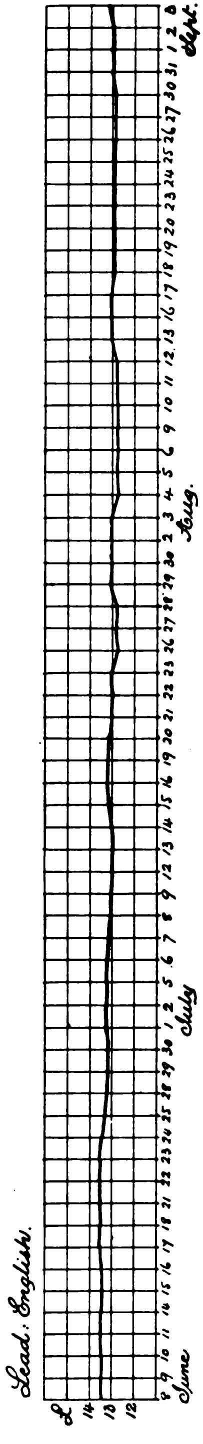
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Cunard Notes.

One of the most pleasurable experiences of the members of the Institution of Mechanical Engineers who attended the recent Congress in Liverpool was the visit to the *Carmania*. Very courteously the Cunard Steamship Company placed this magnificent steamer at the disposal of the visitors to Liverpool, and a party of some 250 ladies and gentlemen availed themselves of the opportunity to inspect the vessel, which lay in the Huskisson Dock discharging a large quantity of copper ingots. It was said that copper has been coming forward very freely from the United States of late, which those who know aver is a sure sign of a coming boom in the manufacture of electrical appliances. The *Carmania* is well known to engineers as the first of the great liners to be fitted with steam turbines. Her principal dimensions are:—

Length	675ft.
Breadth	72ft. 6in.
Depth to boat deck	80ft.
Gross tonnage	20,000 tons
Indicated H.P.	21,000

The building of the *Carmania* started in February, 1904, and she was launched on 21st Feb., 1905. After this much time was spent in a series of experiments and tests to demonstrate the efficiency of the turbine equipment, the result being that the final completion of the vessel for service was delayed until December of the same year. However, this delay was extremely profitable, and resulted in the superiority of turbine propulsion being proved, and, as everyone knows, led to the building of the *Lusitania* and *Mauretania*, the fastest and most perfect of cargo-passenger liners afloat.

The public rooms of the *Carmania* are beautifully designed and luxuriously fitted; they are well lighted and ventilated, and altogether excellently appointed—in fact, they constitute the high-water mark of ocean travel accommodation. On board this floating hotel the state and sleeping rooms are equipped in keeping with the most modern and luxurious land hotel practice, and the occupant has only to touch the electric button to find his wants ministered to as he would in the finest hotel ashore. Needless to say, the passengers' quarters were much admired by the visitors, and the ladies at afternoon tea had an opportunity of forming an idea of how passengers are catered for at sea. The gentlemen of the party were disappointed to find the engine room labelled "No Admittance," the reason being, as explained, that it was deemed advisable by the authorities to open one of the turbines so that the Government officials concerned could satisfy themselves that everything was fit and proper for another year's work.

Of course, the chief interest on the *Carmania* from the engineering point of view centred in these turbines, which drive three propellers, and which in contrasted working with the reciprocating engines of the sister ship *Caronia* furnished the Cunard Steamship Company with valuable data for the construction and engining of the mammoth Cunard express steamers.

It is interesting to note *en passant* that the *Carmania*, *Lusitania*, and *Mauretania* are the only turbine steamers running between Europe and the United States. The latter vessels are, as they have been since their keels were laid, well in the public eye, each voyage being watched from both continents with the greatest interest.

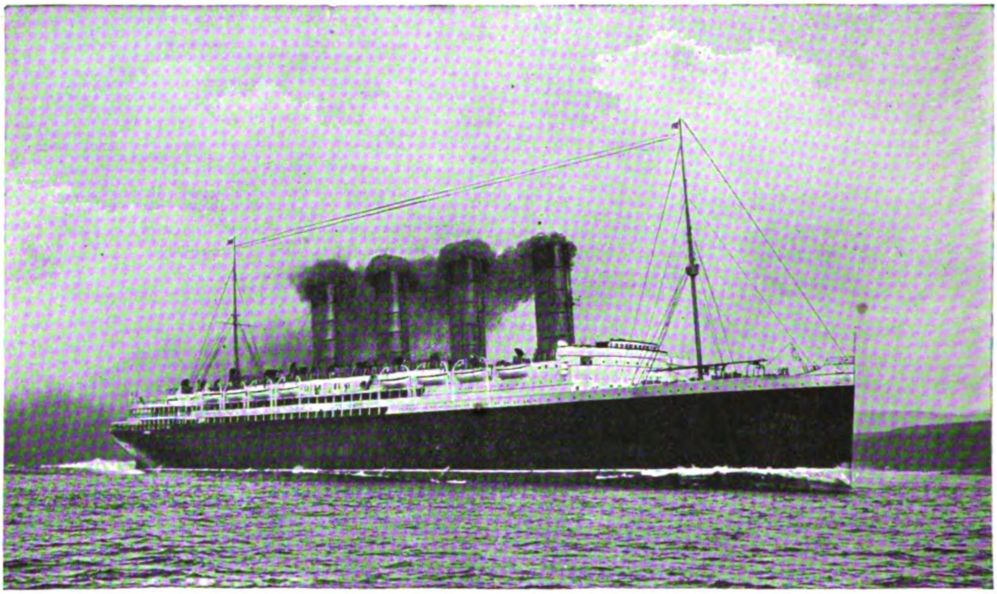
In building the *Lusitania* and *Mauretania* the Cunard Steamship Company decided to secure the best of shipbuilding practice, as exemplified by the experience of those celebrated shipbuilding rivers the Clyde and the Tyne. Accordingly the *Lusitania* was entrusted to Messrs. John Brown and Co., Clydebank; and the *Mauretania* to Messrs. Swan and Hunter, Wigham Richardson, Wallsend-on-Tyne, with the most successful results. The type of propelling power decided upon was that of the steam turbine, and as the largest turbine steamer then afloat was the *Carmania*, the policy of building two turbine steamers of 32,000 tons gross and 25 knots speed evoked world-wide interest. The building, the launch, the completion, and the ocean steaming of these unique ships have been regarded as of international importance, and the doings of these famous vessels are known the world over. Their leading dimensions are:—

Length	790ft.
Breadth	88ft.
Depth of deck boat	80ft.
Draught fully loaded	37ft. 6in.
Displacement on load draught	45,000 tons
Horse-power of turbine engines	68,000
Height to top of funnels	155ft.
Height to mastheads	216ft.

The hulls are fitted with bilge keels to prevent rolling. The double bottom is carried well up the sides of the ship, and this, combined with the fact that the water-tight doors communicating between the different compartments below the water line can be closed automatically from the navigating bridge, ensures that the ships are as safe as any floating structure can be.

In point of speed the *Lusitania* and *Mauretania* have more than fulfilled what was aimed at, viz., an average sea speed of 24½ nautical miles an hour, by crossing the ocean at a speed of 25 nautical miles. Great size and high speed, however, are only two characteristics of these ships. The passenger is perhaps more directly concerned with the comfort which his floating hotel provides, and in this connection it may be said that both public and private rooms, kitchens, &c., if they are equalled, are certainly not surpassed by any of the leading hotels ashore. In short, the highest and best in hotel life is adapted to the

DINING-ROOM OF THE "MAURETANIA."



THE "MAURETANIA."

ships. There are smoke-rooms, lounges, verandah cafés, libraries, and writing-rooms, orchestras, daily newspapers, telephones in the staterooms, and electric lifts to convey passengers from one floor to another. There are spacious promenades, cosily-seated entresols, and last, but not least, a cuisine replete with all the delicacies of the season, and designed to meet the varied tastes of the cosmopolitan travellers who cross the Atlantic on these vessels.

Throughout both ships great use has been made of electricity; in the kitchens as well as the navigating rooms electricity is largely in evidence, having been employed to a far larger extent than on board any other vessels.

In matters of speed both ships have more than satisfied the Admiralty and the expectations of owners and builders. Both vessels have established records for the Atlantic passage, and they are constantly improving their figures, the competition resting now between these two sister vessels, each of which has reduced the voyage between Europe and America down to a trip of about four days.

The Drying of Transformer Oil.

A NEW method of removing all moisture from transformer oil consists of employing a quantity of metallic sodium, which in contact with water forms caustic soda and liberates hydrogen. The oil is put in a special tank, and sodium is added in small quantities at first, about 25grms. of the sodium per hectolitre of oil. The liberation of hydrogen indicates the presence of water, and sodium is added until the evolution of gas ceases. The amount of sodium required naturally varies with the quantity of the oil, but on an average ½kg. of sodium suffices for 1 hectolitre of oil. The oil is well stirred three or four times a day, and after three or four days it can be drawn off and used. The caustic soda remains at the bottom of the tank. The same principle has been used for drying the oil whilst it is actually in the transformer, and with the core and windings in position. In this case the method is to use sticks of sodium on iron wire cores. This has the advantage that the sodium or caustic produced does not come into contact with the windings.

THE
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AND
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An Illustrated Magazine Devoted to the Electrical, Engineering, Shipbuilding, Iron and Steel Trades.

VOL. XII. 15 OCTOBER, 1909. No. 4.

MODERN VALVES.

WHILST much has been written about the progress which has been made during recent years in connection with the design and construction of practically every other component part of steam power equipment, the subject of pressure control valves has received little or no attention at the hands of the technical writer. The reason for this is difficult to see. It may be that the subject has been deemed of little consequence, or held to be devoid of interest. Be that as it may, the result of the peculiar neglect has been that these most interesting and important accessories are little known, and that only through the medium of makers' or factors' advertisements, to the majority of engineers and steam users. In many situations valves of a totally unsuitable design and character are inefficiently performing duties which some other type or pattern would perform effectively, and without trouble or waste.

Too often is it said, in effect, that one stop-valve is as good as another, and that the only thing which needs consideration in connection with these appliances is the question of first cost. If the total costs of the valve, that is, first cost, cost of installing, cost of repairing, cost of renewals, cost of steam or water wasted, cost of labour, and cost of worry, were added together and considered, how different the selection would be in many cases. Perhaps in valves more than in any other part of the equipment is it true that the best and most suitable is by far the cheapest in the long run.

In regard to general construction, every engineer knows that the main parts of valves are constructed of steel, iron, nickel, brass, or bronze castings, which are afterwards machined and finished in accordance with the requirements of the special service they are called upon to perform. The greatest skill of the valve maker has been brought to bear on the construction work, especially in the manufacture of these castings. Careful inspection is required and given at every stage of the manufacture, from the time the patterns leave the pattern shop to the time the finished valves are sent out to the user. High-class makers rigidly test every valve for considerably more than the extreme amount of pressure that will be placed upon it. A valve designed for a working pressure of 300lb. to the square inch is generally tested up to 800lb., or even more, in order that a sufficient margin shall be provided for water-hammer, contraction and expansion strains, unusual shocks, or stresses over and above the working pressure. During the tests the slightest flaw or weakness is sufficient to condemn the particular portion of the valve in which it exists; the faulty part is removed and scrapped, and a sound portion substituted, until it is certain that the finished product will be thoroughly satisfactory and perform its duties in the way the maker desires. It will be seen, therefore, that the low first cost valve is a risky investment. It may be of good quality, it may do its work well; but it should be obvious that it cannot have been the object of such careful attention and testing as one of much higher price.

Further, the conditions of service must enter into consideration in addition to first cost. Where ordinary globe valves are required, no one would dream of using valves with soft rubber discs for hot water, or any other than special discs for high-pressure steam service. Yet globe valves may be put in where gate valves would be more suitable without the matter receiving the slightest consideration.

Before dealing with the many types of valves which are most suitable for different purposes, it may be pointed out that, as a general thing, valves are greatly neglected during their period of service. Not only are they occasionally ill-chosen for the work they are called upon to do, but they are badly installed, placed in unsuitable positions, subjected to what is tantamount to ill-treatment during use, and roughly abused, until the long-suffering mechanism gives way, and it is necessary to withdraw the valve for repair. And it may further be affirmed that, owing to the small amount of information which has been given out concerning the proper treatment of valves in general, the principal cause of this neglect is ignorance, and not carelessness.

Although the majority of engineers are fully aware that a valve is, or should be, a carefully made and delicately constructed piece of mechanism of a high order, carrying out an important task under generally very severe working conditions, yet there are those who do not realise this. Steam users are not always engineers—as a matter of fact, seldom is this the case—and they generally leave all questions affecting valves to the judgment of their mill-engineer or driver, a man who seldom possesses the knowledge of the man who has received a lengthy training in the mechanical engineering profession.

The principal cause of neglect being, therefore, ignorance, it will be well to spend a few moments in reviewing the conditions under which pressure control valves may be required to work, and seeing what recommendations can be made which will have the result of increasing the life of the valve, and enabling it to perform its duties in a better and more satisfactory manner.

In all long lines of steam or hot water piping considerable contraction and expansion is experienced with temperature and other variations, and if a valve is inserted in such a pipe line without some adequate protection against such strains, trouble will almost certainly be ultimately experienced, with the result that the valve will fail long before it would under fair conditions of working. Suitable expansion joints or bends must be inserted in the line of piping in order to take up strains due to length variation.

It is not an uncommon thing to see a valve fixed some distance from a pipe support, or even near the centre of a length of pipe, supported only at its extreme ends. Few realise that in such instances a very large proportion of the weight of the pipe line is being borne by the valve, and good practice dictates that even if it is impossible to relieve the valve entirely of the weight of the pipe, it is at least necessary to support the pipe in good alignment on one side of the valve, and as close to it as possible.

Every engineer, and practically every mechanic, will make certain, before he fixes a valve in position, that there is neither grit nor dirt present in the valve itself, and that the seatings also are perfectly clean and free from foreign matter. But how many think of unscrewing the lengths of pipe on the inlet side of the valve, and well jarring or hammering them, in order to clear out all the scale, rust, grit, or other harmful substances, before coupling up the valve? Not only is such a course necessary before a valve is fixed on an old line of piping, but when a new line is being run the lengths should be jarred and cleaned before erection. As soon as possible after the valve is fixed it should be opened full bore and the piping blown through at high pressure to still further ensure its perfect freedom from dirt.

Further, when the valve is being fixed in position care should be taken to see that the pipe-fitter does not inadvertently, or through ignorance, apply the wrench to the "far" end of the valve. Many light patterns of valve have been permanently injured through this special form of carelessness.

A too liberal use of red lead and spunyarn is also answerable for a certain amount of trouble with valves. It is a common practice amongst some erectors to smear red lead into the female thread of the valve, as well as putting an ample quantity on the male end of the pipe. The pipe is certain, if this is done, to push the red lead into the valve, where portions may lodge on the seating, creating high spots, and so causing leakage and cutting of the valve seat. A further trouble sometimes experienced which may be dealt with here is caused by the erector tapping the pipe too far, and too small, with the result that, in screwing up, the end of the pipe buts up against the seating and jams it out of shape. Tapping up the pipe too far also almost always results in a leaky joint.

Care should also be taken in closing a valve. The writer has seen hand wheels with iron rods bolted across them, so that the attendant could get a greater leverage and so in his opinion shut down the valve tighter. It may be taken that any extra leverage of this kind is unnecessary, as well as undesirable, when the valve is the production of a high-class maker. Sufficient power to shut down the valve can always be applied by the hand wheel, and if a tight joint cannot be made without extra leverage it is evident that the valve seating is out of condition, or that dirt has jammed on the seat. An examination of the seating will show the fault, and it may be incidentally remarked that it is less expensive to examine a valve seat than to buy a new valve.

Should the valve require regrinding or other repair, and it be considered advisable to remove it from the pipe line for the purpose, care should be taken to gently tap the bonnet with a lead hammer before screwing it off, so as to break the joint. The valve should also be opened a little so as to avoid any risk of straining the seat, after which the bonnet may be screwed off without risk of damage. When screwing or unscrewing valves and valve parts, wrenches made to fit accurately, with good square, unworn jaws must be used. Monkey wrenches or screw spanners are of little use unless almost new, and pipe tongs, which are often employed, should never be used.

It is only in comparatively recent years that steam specialities have been manufactured to any extent; and in connection with the appliances which are being dealt with in this article, it is probable that no other type of valve has commanded such a large demand as the regrinding type. The growing tendency towards the use of high-steam pressures has undoubtedly done much to create this, as there is no doubt that the ordinary type of valve is quite unsuitable for high-pressure work. It has been found in practice that the majority of valves with rubber, leather, and soft metal discs generally are only suitable for low-pressure work, for which, indeed, they are very satisfactory. When higher pressures are used they lack durability and wear badly. The discs and valve seatings rapidly corrode, and it is almost impossible to keep such a valve steam-tight for any length of time. With such valves, also, the cost of maintenance is excessive, since the discs and other incidental parts frequently require renewing in order to secure a tight bearing.

The cost of these renewals soon amounts to more than a specially constructed regrinding valve would have cost in the first place.

The best type of regrinding valve is probably that in which a very hard bronze composition is used in construction. In addition to a good quality of material, the design should be on generous lines, having strength and durability as a main object, because the valves, to prove their superiority to other types, will have to withstand very long and severe usage. The restrictive area of the valves should be very largely in excess of the pipe, and in the design care should be taken to ensure the curves being of as wide a radius as possible, in order to oppose a minimum of resistance to the passage of steam or other liquid. The parts subject to the greatest strains should be heavier in proportion, whilst the threads should be well cut and have full depth.

One of the most common troubles which have to be contended with, and a defect which is inherent in the majority of types, is in connection with the threads on the operating spindle. These frequently strip, and the design should be such that the threads on the stem and hub should be fully utilised with contact throughout their entire length when the valve is closed and sustaining the greatest strain. A common fault in construction is that the stems are made of too small a diameter.

In most forms of valves, in order to gain access to their interior, the hub, or bonnet, which has a male thread and screws directly into the body, has to be removed. After valves of this pattern have been in use for any considerable length of time, the action of the liquid corrodes the threads and renders it eventually very difficult to remove the trimming from the body. A valve has been introduced in which this difficulty is obviated in a very neat manner. The trimming is designed so that it is firmly attached to the body of the valve by means of a union ring connection. This feature has many decided advantages, as in addition to its being a comparatively easy matter to remove the trimming when for any reason it is necessary to inspect the valve body, the threads being on the outside are not exposed to the injurious action of the steam, and so are not liable to corrode.

In the particular valve under description, the method by which the disc is secured to the spindle, or stem, is extremely effective, and would seem to be superior in many respects to any other method adopted. A lock nut is provided which slides over the operating stem and is screwed into the disc. To remove the disc at any time from the stem, all that has to be done is to place the nut on the bottom of the disc in a vice, and remove the lock nut with a spanner in the ordinary way.

In addition to this useful feature a packing recess of ample depth and capacity is provided, the larger sizes being fitted with a double-seated packing gland, which is easily removable with a screwdriver or other flat instrument when it is necessary to repack the valve.

There is no difficulty in fixing, repacking when necessary, or regrinding valves of the pattern described; but as they are free from all complications they are often subjected to more ill-usage than valves of a more elaborate pattern. This is due to the fact that, by reason of their extreme simplicity, they are not infrequently placed in the hands of comparatively inexperienced and often altogether incompetent workmen. When this is the case, damage is frequently done in a manner which would almost seem impossible.

Yet the simplicity of all operations is shown very graphically in the illustrations, Figures 3, 4, and 5, which were provided by the D. T. Williams Valve Company. These not only clearly illustrate the ease with which the valves may be repacked, but also show the steps necessary to take for regrinding the valves.

To repack the valve under high pressure, the valve must be opened to its fullest extent. It will be seen from the sectional drawing Fig 2 of a typical regrinding valve that this causes the small seat on the stem to come into close contact with the bottom of the bonnet, which thus causes an absolutely steam-tight joint. Valves fitted in this way are always subjected to very rigorous tests of this feature in order to prevent any accident to the operative.

The following description, read in connection with the illustrations, fully explains how the regrinding of valves of this pattern is carried out. The first thing which has to be done is to remove the union ring mentioned, which secures the trimming to the body of the valve. This is not a difficult operation, as it is seldom necessary to screw this down until practically solid with the valve, and as has been mentioned the threads rarely corrode, because they are not exposed to the corrosive action of lime or steam.

When the trimming has been removed the disc on the stem should be turned until the slot in the lock-nut is in line with the hole in the stem. The pin should be inserted through this hole, and the disc is now securely locked in position. When the regrinding is completed, however, this pin must be removed, as it is essential that the disc should freely revolve on the stem whilst the valve is in use.

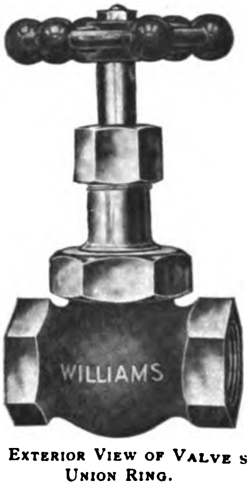

FIG. 1. EXTERIOR VIEW OF VALVE SHOWING UNION RING.

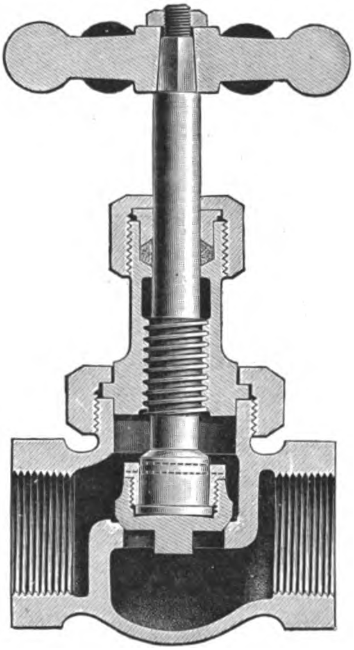

FIG. 2. SECTION OF WILLIAMS' REGRINDING VALVE.

Many engineers prefer to use bath-brick for grinding valves, holding that when emery is used it is practically impossible to remove all traces of emery from the seating, with the result that the residue is constantly cutting the seating and the disc. It may be that this is correct from a theoretical point of view, and may even have some foundation in practice where the operator is very careless. At the same time it may be said that the danger is more apparent than real. Whatever grinding agent is used it should be applied to the disc and the trimming returned to the valve body. After this is done the bottom of the hub of the bonnet should be allowed to glide in the neck of the body and the trimming rotated backwards and forwards. There is no need, unless the valve is in very bad condition, to press heavily on the valve, nor to rotate for any great length of time. When completed and all traces of the grinding agent are cleaned away, the valve, if the regrinding has been carefully done, should be practically as good as new.

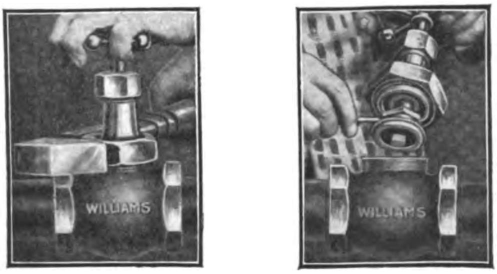

FIG. 3.

Regrinding valves can, of course, be obtained in globe, cross, or angle patterns, with female tapped or flanged ends, suitable for working steam pressures up to 350lb. to the square inch. They can also be obtained with outside screw and yoke, with screw or flanged ends.

The double disc gate valve is a type which is by many considered superior, even in small sizes, to other types, and an article on modern valves would be far from complete without a description of the most recent patterns of this type of pressure-control valve.

A correctly-designed and constructed gate valve should be so proportioned as to offer an absolutely unrestricted passage to the fluid passing through. The problem contained in the above requirements has for many years engaged the attention of engineers, and many forms of gate valves have been placed on the market, some of which have been far from successful, whilst others have met with considerable success.

The single solid tapered wedge type of gate valve is the most simple form on the market, and this consists of one tapered wedge fitting an angle made by the seats in the valve body. There are no spreading devices needed for this form, and whilst it is strong and suitable for comparatively high pressures, it is light, compact, and inexpensive to manufacture.

One of its principal drawbacks is its rigidity, which allows no compensation for the contraction and expansion strains which are inseparable from valve work, whilst shocks or sagging of the pipe line are liable to distort the valve body more or less, impairing the alignment of the wedge and seats. This causes more or less serious leakage, with resultant cutting. Should a particle of scale or dirt settle on one side of the wedge or on one seat, a high spot is formed which forces the wedge out of its proper position, and so springs the body. Further, there is a risk of the valve being considered closed when it is really partially open. This is on account of the pocket formed by the two seats collecting any sediment, scale, etc., which passes through the valve. As may be readily imagined, a small quantity of this is sufficient to obstruct the full travel of the wedge.

A further disadvantage of this type of valve is that it is necessary to use considerable pressure in driving home the wedge after it comes into contact with the seats. The valve seating is scored and worn by this constantly recurring pressure, and the valve becomes unsound. These drawbacks are the more serious as repairs can seldom be effected in a local workshop, but must, as a general thing, be carried out by the valve manufacturer at his own works.

The double parallel disc valve was introduced after many years of experiment, and quickly became popular, inasmuch as it was a great improvement upon the earlier types. It was designed with a view to avoiding that degree of rigidity which had proved such a drawback to the single solid tapered wedge valve, and it certainly showed itself remarkably flexible in opera-

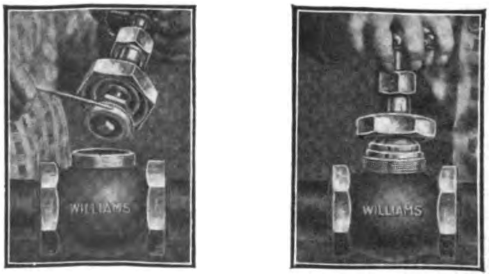

FIG. 4.

tion. This flexibility was gained by the use of two parallel discs, two parallel seats, and self-adjusting spreading mechanism of different kinds. The principle of working is that when the discs are opposite the ports, the travel is retarded by an obstruction which automatically expands the spreaders, causing a lateral movement of the discs against the seats, and so closing the valve.

For this type of valve wider face-to-face measurements were required, as larger recesses were necessary to accommodate the spreading devices. This naturally exposed a larger area of metal to the action of the steam or other liquid. The bodies of the valves had naturally to be made heavier by reason of the extra bulk, but as the tendency was to cut down weight and size as much as possible, many valves of this type were unsatisfactory; they were weaker and more costly, and although their disadvantages were not so pronounced as in the earlier type they were, nevertheless, quite appreciable. For example, the complicated spreading devices were frequently deranged, and particularly was this the case where the valves were required to be operated in any other than a vertical position. Also slight obstructions occasionally caused the spreading devices to set prematurely, thus giving the operator the impression that the valve was closed when in fact it was partially open. As, however, no valve of a more reliable character was obtainable, the double parallel disc type enjoyed a fair run of popularity.

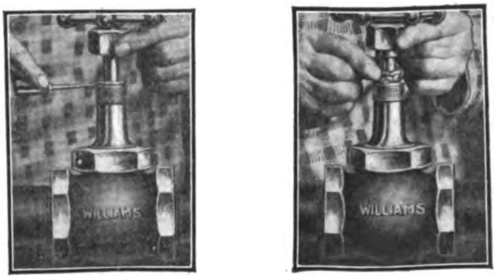

FIG. 5.

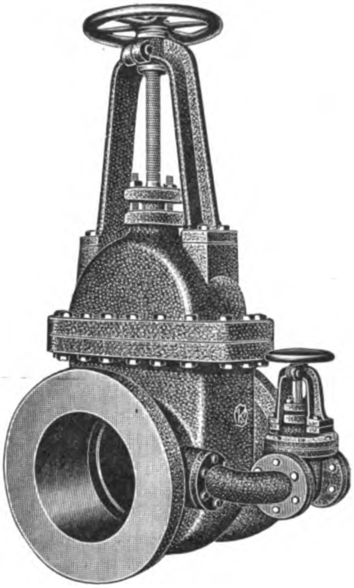

FIG. 6. LENTICULAR GATE VALVE, SHOWING BYE-PASS.

It is probable that the Nelson Valve Company of America were the first to materially improve upon this type when they introduced the double disc taper seat valve. The objects sought were freedom from the defects of the earlier types, adaptability, reliability, and inexpensive character. The valve, to be as nearly perfect as possible, should be strong, compact, and heavy, the mechanism should be flexible and of the simple disc and wedge pattern, providing conformity to any distortion of the valve body which might be caused by either accidental shocks or the severest strains caused by contraction or expansion. The construction should be such that scraping or scoring of the discs or seats was practically impossible, there should be no risk of derangement, and the discs should travel easily until the ports were completely closed. The introduction of the Nelson double-disc mechanism, which consisted of only three parts, namely, one central wedge and two tapered discs, marked a great advance in the manufacture of modern valves.

In this type the discs are so constructed that they automatically rock into any position required for perfect seating without any other spreading device than the simple wedge on which they are carried. A further feature is that this rocking into position takes place without risk of failure whether the valve be in an inclined, horizontal, or vertical position.

The makers claim that the flexibility of the disc mechanism fully compensates for any temporary or permanent derangement of the angles of the seats that may be caused by the severest strains or by contraction or expansion. It is said that even if one of the discs should be obstructed by particles of scale or dirt, the central compound action of the wedge applied to the rocking feature of the disc compels the other disc to close up so tightly that the valve remains perfectly steam-tight.

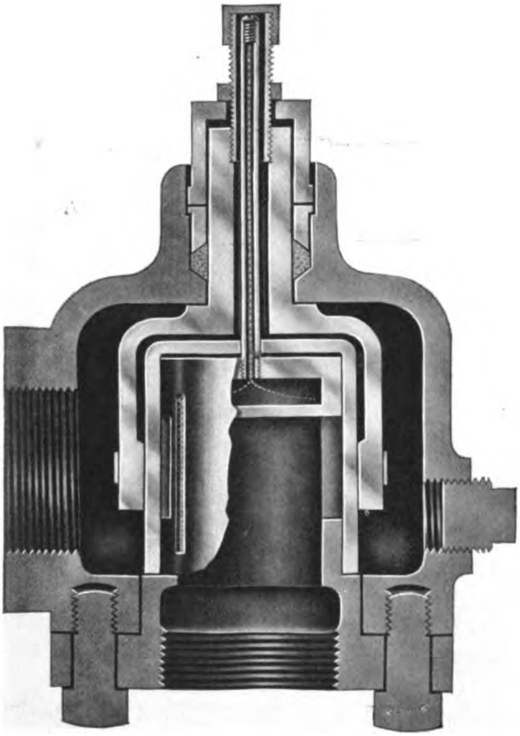

Fig. 7. Section of Rotary Gate Valve.

The discs are arranged to ride on guides that fit grooves in the valve body, and the design is such that they make no contact with the seats until they are driven completely home. This prevents the faces scraping at any point, and gives longer life to the parts. The perfect adaptation of this type of valve to extreme variations in temperature renders it particularly valuable in plants where it is necessary to open and close them frequently to give alternate supplies of live steam and cold water. The sediment which in such cases frequently collects in the pocket formed by the seats is squeezed between the discs when they are closed, so that when the valve is next opened it is carried up with them and washed away. Owing to the simplicity of the design it is impossible to wrongly assemble the parts, and their freedom in movement prevents any possibility of jamming.

Additional strength without increased bulk was obtained by shortening the face-to-face dimensions and reducing the recess provided for the working parts. A short valve body was thus secured in which the least possible area of metal was exposed to the working pressure, whilst at the same time the various factors were compounded, resulting in considerable gain of strength. This was further increased by the elimination of the commonly-used straight lines and acute corners which were to be found in some of the earlier models and substituting curves of ample radius in their stead.

Bronze gate valves made on this principle possess superior structural strength, bronze being, as is well known, the most suitable metal for valve construction. Owing to the strength of the metal and the compact design, the parts can be made so that the hexagons are heavy, with long tapped openings for pipes or with flanges of ample thickness as the case may be, together with large-capacity packing chambers and unrestricted opening to the full bore of the line. They are usually fitted with packing gland and outside screwed bonnet in the larger sizes. An interesting form of this valve is one which is operated by a lever for quick opening, provided with a hand wheel which affords a positive grip that securely locks the gates at any desired opening. It is also interesting to note, before leaving the subject of bronze gate valves, that many have been constructed for hydraulic pressures up to 5000lb. to the square inch which are still giving, after some years' operation, most satisfactory results. Not only are these valves manufactured for extreme pressures, but they are able to withstand the severe shocks caused by the frequent alternations of maximum and minimum pressures inseparable from the duties which they are called upon to perform.

Another type of gate valve is that with iron body, bronze mounted, which is similar in construction to the type just described, with the exception that usually the bonnets and glands are bolted on, the bronze seats are screwed into the iron body, and the bronze disc rings are rolled, tongued, and grooved into the iron discs. These valves also offer an unrestricted opening to the full size of the pipe, and possess all the advantages of the bronze pattern, apart from the actual strength of the metal. In the bonnets and glands extra heavy bolts and nuts are usually used, whilst the bolt holes in the bonnet flanges are so accurately spaced that the bolts may be put in place even if the bonnet is moved round a space of a circle. They can be made with rising stems, for positions where it is desirable to indicate the height of the gates, and with outside screw and yoke with rising stem, for situations where it is considered desirable that the threaded parts shall be readily accessible for lubrication, and shall at the same time be free from the action of the steam or other fluid controlled. If the valves are for use with gases or fluids that attack bronze, these valves can be furnished with iron or nickel mountings. Iron body gate valves constructed as described can also be obtained with spigot and socket ends suitable for pipes up to practically any diameter, constructed for working pressures up to 125lb. to the square inch, the valves being usually tested before sending out with at least double the working pressure. The valves can, of course, be supplied if desired with by-pass.

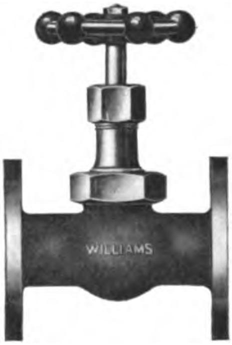

Fig. 8. Globe Valve with Flanged Ends.

Valves of this type can be made, as already mentioned, for extreme hydraulic pressures; for working under such conditions the body of the valve is usually constructed of acid open hearth steel, having a tensile strength of 65,000lb. per square inch, which is considered suitable for valves designed for working pressures of 10,000lb. For extraordinary pressures gate valves can be constructed from special steel with a tensile strength of 120,000lb. to the square inch, so that it will be seen that the modern valve maker is prepared to construct valves which may be relied upon to perform their duties no matter to what special requirements they may be asked to conform.

Extra heavy gate valves are required for

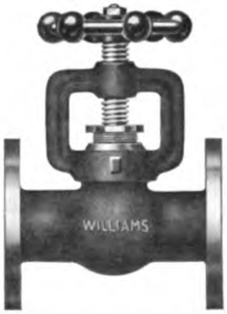

Fig. 9. Globe Valve with Outside Screw and Yoke.

dealing with superheated steam, and these are constructed almost invariably from a high-quality steel on account of the vital importance of having the mechanism for controlling this extremely destructive agent constructed from some substance which can be relied upon to withstand its action. The makers of the Nelson valve describe pressure-controlling devices for superheated steam work as being actually high-class operating machines. To meet the severe conditions, they say that the combination of mechanism, design, and metals used must act in perfect harmony. The most trying of these conditions are the extreme degree of expansion and contraction to which the valves are exposed with superheated steam, the corrosion, which is always a potential factor, the difficulty of packing under pressure and of packing so as to withstand the pressure, the short life of the packing, and the great risk, should any part fail, of danger to the operator.

The double-disc tapered mechanism described is very suitable for superheated steam work. Under the hardest conditions the valve will maintain almost perfect flexibility, and will hold the pressure; whilst at the same time it will automatically adjust itself to any distortion of angle which may be caused by any incidental strain. The body is elliptical, which enables castings to be made at least 50 per cent. stronger than the commonly-used box pattern, and the absence of acute angles renders it possible to make flawless steel castings from acid open hearth steel, which is the only metal safe for temperatures up to 800deg. Fahr.

The discs for this work are usually constructed of nickel alloy, which can be relied upon to withstand corrosion, and has been repeatedly proved to be reliable at extremely high temperatures. If the alloy is correctly composed, the coefficients of the body and discs are almost identical, expanding and contracting practically in harmony. Where the coefficients are not identical it is impossible for the valve to be steam-tight.

Special packings, tested to 800deg. Fahr. are used for the valves, and to facilitate ease and comfort in handling, the wheels are usually covered with some insulating material, as cork. The stuffing-box is generally secured with swing bolts, and is protected from extreme heat by elongated condensing chambers.

Gate valves of the types and patterns already described can be operated from a distance, either by some approved form of gearing, generally taking the form of bevel-wheels on the spindle and a long extension rod, chain-wheel, or spur-wheel gearing, or electrical or hydraulic control. These controls, particularly the two latter, are used to advantage when it is necessary to place the valves either in some inaccessible or dangerous position or when for convenience it is desirable to control them from a distance. In the electrical control system the valve is governed by a switch working a motor fixed parallel to the valve spindle, and connected to it by raw-hide or other suitable gearing. The switch has usually only a high and low limit. Placing the switch in the "on" position starts the motor, which opens the valve. When opened to its fullest extent the switch is automatically thrown off and the motor stopped. The valve is closed in the same way, whilst it can be manually set at any position if required. Hydraulically controlled valves are operated by turning a four-way cock located at some convenient point. A movement of the cock in one direction opens the gates, whilst a reverse turn closes them.

An interesting form of gate valve is that known as the rotary gate, a sectional illustration of which the writer is enabled to give by the courtesy of the John Simmons Co., of New York. This type of valve is very reliable, and it is claimed that if kept in good condition and heated fairly it will hold steam, water, ammonia gas, air, oil or other fluids, either hot or cold, without any adjustment, repairs, or replacing of parts. In the design under notice the old accepted principles are entirely reversed. The gates are entirely surrounded with a uniform pressure, and automatically take up their own wear, and so make a very even and fluid-tight seat. There is no undue strain on the seating parts, and positive stops are provided, within full view of the attendant, to hold the gates in the best position when the valve is closed or fully open.

As will be seen in the illustration, the gates are held in contact by the pressure handle, and are not subject to the strain of differential expansion.

The valve is extremely simple and designed for hard service, and the object in view has evidently been to first have a device of the cock type to prevent cutting of parts, and so constructed that the wear will not result in leakage or in any way affect the efficiency of the valve. The joint through which the steam passes is self-sealing, and the sealing parts can be completely finished in the factory before they are permanently adjusted in the body, making them entirely independent of the body or any part of the seat.

A reference to the illustration will show that the plug has two ports on opposite sides, with one discharge through the bottom. The flexible gates, representing less than a half circle, surrounded the plug in such a way that when rotated the ports in the plug are opened or closed simultaneously for controlling the flow of steam or water. A fork is adjusted over the outside of the gates, and serves to keep them in place.

The bottom or flanged portion of the plug is permanently fixed to the body of the valve by means of stud bolts. It will be seen that the important parts, the plug and gates, never come in contact with the body, consequently they are not only unaffected by any slight variations of temperature, but they are not likely to be distorted by any strain brought on the pipe connections.

The lenticular gate valve which is here illustrated, with a by-pass, in Fig. 6, s made by the Kennedy Valve Manufacturing Co., of Elmira, two rockers are provided between the discs, which are segments of a sphere on which the discs adjust themselves to their seats. There are only four parts which are moved by the action of the screw; these are the two discs, the lenticular bearing or centrepiece and the stem nut. The discs are provided with pockets or recesses into which work projections or shoulders on the stem nut, and from which the discs are suspended. On the back of each disc, the makers explain, is a projection having a concave face and fitting accurately to the convex faces of the centrepiece, thus making a true centre bearing. The construction and relation of the rings on the discs are such that the discs have perfect freedom of movement round the centre.

These discs are also provided with guide wings on either side, which work between the guides cast in the body of the valve, and their function is to control the position of the discs when the valve is being opened or closed. The discs, it will be noticed, are held in a central position by means of these guides, and it is therefore impossible for them to come into contact with the seat-rings except at the very moment of closing the valve. In this way there is no possibility of the faces being injured or scored. The two convex faces on the centrepiece are segmental faces of a true sphere, and are arranged in ring form to allow the stem to pass through. The convex faces of the centrepiece and the concave faces of the projection on the back of the discs conform to each other, and when the valve is closed the discs are forced to their seats from the centre with an evenly-distributed pressure at every point. The action of the lenticular rocker is such that it is impossible to produce any but radial stresses in the discs.

G. Basil Barham, A.M.I.E.E.

(*To be continued.*)

THE DESIGN OF CONTINUOUS-CURRENT TURBO-DYNAMOS.*

The author, in introducing his paper, points out that the immense strides made in the last decade in the construction of steam turbines have set the designer of continuous current generators an increasingly difficult task. This difficulty lies chiefly in the fact that the conditions for highest efficiency in the prime mover and the generator are in point of fact diametrically opposed. Formerly the electrician was always asking for higher speeds; now, suddenly, the speeds of steam turbines have been realised, and they are as much above the mark as the revolutions of reciprocating engines were below it. Very little has been done towards reducing the speed of the turbine, perhaps because the mechanical designer has had the feeling that no doubt the electrician would find a way out of the difficulty; but rather than risk the reliability of a high-speed continuous current dynamo or the loss of efficiency due to a slow-running turbine, designers have avoided the issue by installing 3-phase generators with rotary converters or motor-generators. As a substantial speed reduction seems improbable at present, the author proceeds to draw attention to the various reasons why the dynamo designer cannot raise the speed, or rather what disadvantages and difficulties have to be considered in the event of the present speed limits being exceeded. At the same time he points out the superiority of the fully compounded or compensated machine over the machine with auxiliary or commutating poles, the value of which does not seem to be fully understood at the present time. Finally, the author illustrates cases where the design appears to be successful, giving an illusory impression of reliability, and gives his own suggestions for improving and advancing the construction of continuous-current turbo-dynamos.

Speed Limits.

It is not so much the high peripheral speed of the rotor as certain electrical reasons which limit the output of a machine at a given speed. The materials obtainable nowadays are quite equal to the stresses they are subject to. Consider the armature binders, the most sensitive element in the rotor. The stress for a given speed will be:

$$p = \frac{v^2\gamma}{98.1} \text{ kg. per sq. cm.}$$

where v equals peripheral speed in metres per second and γ is the specific weight of the material. Add to this the centrifugal pressure of the windings which are held in place by the binder, we get:

$$p_1 = \frac{Gv_1^2}{q \times 98.1 \times 2r_1\pi}$$

where G is the weight of copper, r_1 the radius of gyration, and q the cross-section of the binder. Now v and v_1 do not differ greatly, and the ratio $\frac{G}{q}$ is practically a constant, so that we can simplify the above and obtain sufficient accuracy by using

$$p_1 = \frac{4v^2}{98.1}$$

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* Paper read at the Seventeenth Annual General Meeting of the Verband Deutscher Elektrotechniker at Cologne by E. Ziehl, Berlin; translated by H. I. Lewenz, A.M.I.E.E., &c.

Hence total tensional stress in the binder is:

$$p + p_1 = \frac{v^2}{98.1}(\gamma + 4) \qquad \text{(I.)}$$

A bronze can be employed having a tensile stress of 6000kg. per sq. cm., with 15 per cent. to 20 per cent. elongation. Putting these values in above equation (I.), we get a peripheral speed:

$$v_{\text{ult.}} = \sqrt{\frac{6000 \times 98.1}{8.5 + 4}} = 221 \text{ metres per sec.}$$

This is the speed at which the binder would just fracture, and using a factor of safety of 8, as is usual, we get:

$$v_{\text{perm.}} = \sqrt{\frac{6000 \times 98.1}{8(8.5 + 4)}} = 77 \text{ metres per sec.}$$

This figure gives a very large margin of safety, even with a possible overspeed of 20 per cent. to 30 per cent. All the other parts, such as the core stampings, driving arrangements, &c., are quite safe, provided that they are properly designed with due consideration of the mechanical stresses involved.

Electrical Limits.

To obtain sparkless commutation at all loads several conditions have to be fulfilled, and these have been determined chiefly by practical experience.

A well-built commutator and properly balanced armature being, of course, presupposed, we have first to consider the maximum permissible voltage between segments. The figure usually taken for turbo-dynamos is from 30 to 40 volts maximum difference of potential. This figure is purely empirical and has no theoretical basis. We know that at 50 to 60 volts the commutator is apt to flash over and may fire right round from brush to brush. That turbo-driven machines are more subject to this flashing over is probably due to the fact that the reactance voltage of the short-circuited armature coil has a comparatively higher value, owing to the more rapid commutation in these, than in the slower running types of machine.

The permissible current density is governed on the one hand by the available surface area of commutator, which depends on the general design of the machine, and on the other hand by the reactance voltages and voltage between segments. The current can be heavier the less the reactance volts and volts between segments are, or in other words, the smaller the terminal pressure of the machine. In practice the value of the current in different machines has reached from 700 to 1000 amperes per brush spindle. The current density is further limited by the number of armature conductors and the permissible temperature rise of the armature, which is proportional to

AC = ampere conductors per cm. of the armature circumference.

AC varies according to the size of the machine, being in general greater for a machine of higher output. The theoretical limit is given very closely by:

$$AC \times \text{current density per conductor} = \text{a constant} \times \text{temperature rise of armature.}$$

Hence, for equal rises of temperature AC can be greater for larger machines, because in larger machines the current density is less than in small ones (see Fig. 1). The output of a continuous-current dynamo for

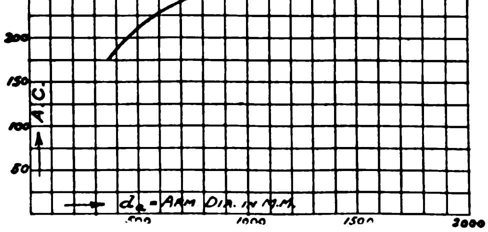


FIG. 1. VALUES OF AC FOR DIRECT-CURRENT MACHINES.

a given speed is determined as follows, using the symbols:

E = E.M.F. of the machine.
J = Total current of the machine.
B = Flux density in the air gap.
l_a = Length (effective) of armature conductor.
d_a = Diameter of armature.
v = Speed of armature conductors.
N = Number of armature conductors.
k = Number of paralleled circuits in the winding.
$\frac{b}{t}$ = Ratio $\frac{\text{pole width}}{\text{pole pitch}}$
e_s = Voltage of segments in a uniform field.

Then we have the fundamental formula:

$$E = Bl_a v . \frac{N}{k} . \frac{b}{t} . 10^{-8}$$

and the output in kilowatts will be:

$$EJ = \frac{b}{t} Bl_a v N \frac{J}{k} . 10^{-8} \qquad \text{(II.)}$$

Now $N\frac{J}{k} = ACd_a\pi$, and substituting we get:

$$EJ = \frac{b}{t} Bl_a v d_a AC . 10^{-8} \qquad \text{(III.)}$$

Further, we have the voltage of one segment when there is only one conductor per coil, as is usually the case in turbo-dynamos:

$$e_s = 2Bl_a v . 10^{-8} \qquad \text{(IV.)}$$

Substituting this value in III. and assuming $b/t = 0{\cdot}7$, which is about a maximum, we get:

$$EJ = 0.7 \frac{\pi}{2} e_s ACd_a$$

or, simplifying:

$$\textit{Output} = EJ = 1.1\, e_s ACd_a \qquad \text{(V.)}$$

which shows the important fact that the *output of a continuous current machine is proportional to the product of the voltage of one segment × the number of ampere conductors per cm. of the periphery × the diameter of the armature.*

In order, therefore, to obtain the highest output for a given number of revolutions, we must make these three factors as high as possible. From the flattening of the curve in Fig. 1 it is clear that as regards AC we are near the limit. An increase in this factor would demand extra ventilation or artificial cooling. As the voltage between segments e_s is limited for reasons of commutation, it is clear from equation IV. that for a given number of revolutions the product length of conductor l_a × flux density B is fixed. Experience in the construction of larger machines shows that these values can be well maintained, but in medium and smaller machines one is forced to reduce e_s in order to prevent either l_a or B from being unduly reduced. In the cases where, for instance (in equations II. or III.), the value of J/k (otherwise stated AC) is limited, on account of the size of the commutator or for other constructional reasons, and if E had to be kept low (*i.e.*, in low voltage machines), the reduction of one of the factors B, l_a, or v (equation IV.) is unavoidable. We should not reduce B, if only to avoid altering the ratio of field ampere turns to armature ampere turns. We are forced, therefore, in order to reduce e_s, to diminish either the length of armature l_a or the peripheral speed v. In medium and small-sized machines therefore, in order not to reduce the length of armature unduly, there is only one thing left, and that is to reduce v, *i.e.*, *to reduce the revolutions of the machine rather than increase them to meet the requirements of the turbine builder.*

From the above considerations, and with the given limiting values for AC, v, or e_s, we are able to fix the maximum possible outputs for different speeds of the machine, according to the formula given in equation V. Values of AC for different diameters of armature are read off the curve in

Fig. 1; d_a is governed, for any particular speed, by the permissible peripheral speed *(v perm)* found by equation I.; we will take this in round figures to be 75 metres per second. The permissible voltage between segments we will take at $e_s = 30$ volts to ensure good commutation. Under these conditions the calculated outputs are obtained shown in Table I.

TABLE I.

OUTPUTS CALCULATED FROM EQUATION V.

Revolutions per m. n	Diam. of armature. da.	Maximum Output. kw.
3500	41 cm.	260
3000	47·9 ,,	320
2500	57·5 ,,	415
2000	71.8 ,,	565
1500	95·5 ,,	800
1000	143·5 ,,	1400
750	192.0 ,,	2000

Comparing these figures with Table II., which gives particulars of actual machines built by Messrs. Brown, Boveri, and Co., it will be found that the calculated values are in fair agreement with the outputs for the 550 volt machines, whereas, compared with the 240 volt and 120 volt machines, the outputs in Table I. are too high. This goes to confirm the previously established theory that the voltage of the segments e_s, in medium and low pressure machines, must be reduced in order to maintain a reasonable length of armature, and this reduction, as a rule, demands a reduction of the peripheral speed.

Low-pressure high-speed machines are, therefore, very limited in their maximum output, while with higher pressures the outputs can be much higher because the segmental voltage can be increased in direct proportion to the increased diameter of the commutator and inversely as the number of revolutions.

TABLE II.

SPEEDS AND OUTPUTS OF HIGH-SPEED CONTINUOUS-CURRENT GENERATORS, TYPE T.S., BY BROWN, BOVERI AND CO.

550 volts.		240 volts.		120 volts.	
R.p.m.	Kw.	R.p.m.	Kw.	R.p.m.	Kw.
3500	100	—	—	—	—
3200	150	3200	100	3000	100
3000	200	3000	150	3000	150
2800	300	2800	200	2700	200
2500	400	2600	300	2400	250
2100	500	2300	400	—	—
1800	650	2100	500	—	—
1500	850	—	—	—	—
1250	1100	—	—	—	—
1000	1500	—	—	—	—

If we now compare the speeds and highest outputs from the calculated values of Table I. with the outputs for different speeds of standard Parsons turbines (shown in Fig. 2), we see how far short the results obtainable by the dynamo designer are from satisfying the requirements of the turbine builder.

In order, therefore, to use up the available power of the turbine, it has been necessary to couple two dynamos on one shaft. But this cannot be looked upon as a satisfactory solution, if only by reason of the high cost and the diminished efficiency of two generators instead of one.

The present tendency of building continuous-current units for very large outputs

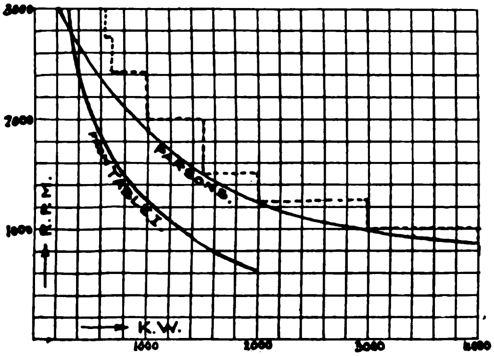


FIG. 2.

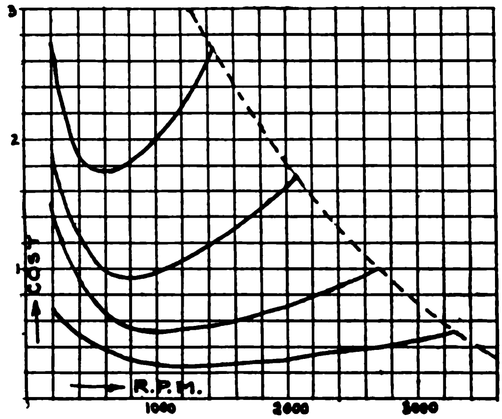
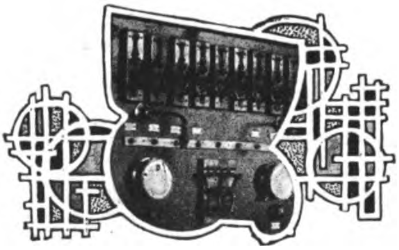


Fig. 3.

points to the selection of a comparatively slow speed prime mover.

Further confirmation of this tendency is obtained by a consideration of the comparative cost of building dynamos of similar output for different speeds. The curves in Fig. 3 were compiled from various makers' prices. In these curves the prices are plotted as a function of the speed. The figures are only relative; they do not indicate actual prices, and, naturally, there will be variations of price for different conditions; but, at all events, the figures will show the same general characteristics, and that is all that is necessary for this demonstration. The dotted line cuts the curves at the price for the highest obtainable speed for any particular output, and it will be seen that the least cost of the same machine coincides with a speed which is only from $\frac{1}{2}$ to $\frac{2}{3}$ as high as the maximum obtainable.

(*To be continued.*)



BALL AND ROLLER BEARINGS.

(Continued.)

IN the products of the Standard Roller Bearing Co., of America, the rollers are held in a cage as usual, but the special point is that there is a ball bearing between the ends of each roller and the cage, preventing all wear on the cage, permitting freedom of movement, and keeping the rollers in true alignment.

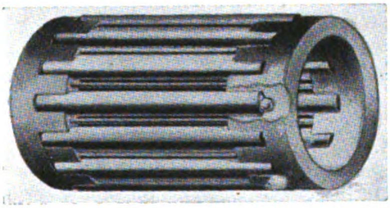


Fig. 17.

This is shown in Fig. 17, and constitutes a very original feature. Hardened and ground steel sleeves are supplied for putting the bearing on to the shafting. To this firm belongs the honour of having made the largest roller bearing ever constructed, which is of 38in. diameter, and is shown in Fig. 18. A rather interesting roller-bearing trolley wheel is shown in Fig. 19. A hardened steel sleeve is mounted inside a bronze wheel, and the bearings can be taken off the worn-out wheels and put into new ones. They last considerably longer than the usual type of trolley wheels, do not heat, and want no attention. They are, therefore, worthy of the notice of tramway managers who wish to reduce their maintenance costs in this direction. A very interesting comparison between the energy taken by ball bearings of the standard type and the ordinary ring-oiler bearing is shown in Fig. 20, consisting of curves of commercial efficiency on interpole varying-speed motors. The field resistance losses are not included, but the difference between the two curves is sufficiently obvious to demonstrate the value of ball bearings in this connection. The saving in power consumption is also demonstrated from the following figures, obtained from a test on two tramcars under practically the same conditions. The test was made on a three-mile run, nearly straight, except for one short curve of 90deg. Car No. 1 was equipped with roller bearings, while the second car had the ordinary plain bronze bearings. The amperes and volts applied

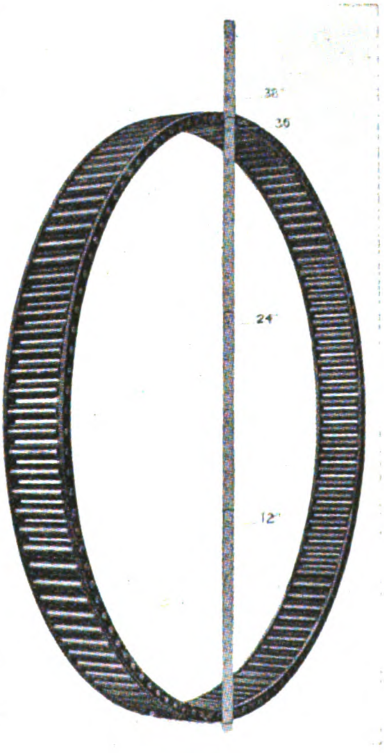


Fig. 18.

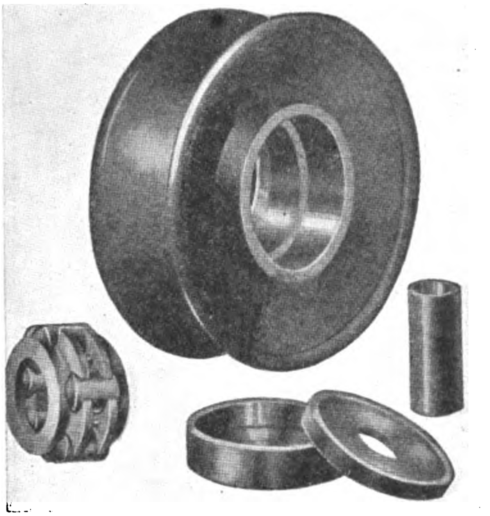


FIG. 19

were measured by calibrated Weston meters, and the power consumed included controller losses. The readings were taken every six seconds, and the time of runs and the consumption of energy were as follow :

	Time in Minutes.	Kilowatt Hours.
Car No. 1.		
Outward Journey	18.1	1.94
Return Journey	16.7	1.16
Total	34.8	3.10
Car No. 2.		
Outward Journey	19.1	4.42
Return Journey	16.1	2.03
Total	35.2	6.45

The saving secured may seem extraordinary, but it was confirmed by further tests, in which it was demonstrated that the nett cash saving in coal consumption or its equivalent was £58 per annum, in addition to which there was a very considerable saving in the wear and tear occurring on ordinary bearing brasses. Fig. 21 shows the type of roller bearing adopted for motors where there is a certain amount of lateral motion, the bevelled ends of the rollers preventing them from bending or twisting and keeping them always in perfect alignment with the shafting. The Grant bearing, also by the Standard Roller Bearing Co., is shown in Fig. 22. This has conical tapered rollers, with

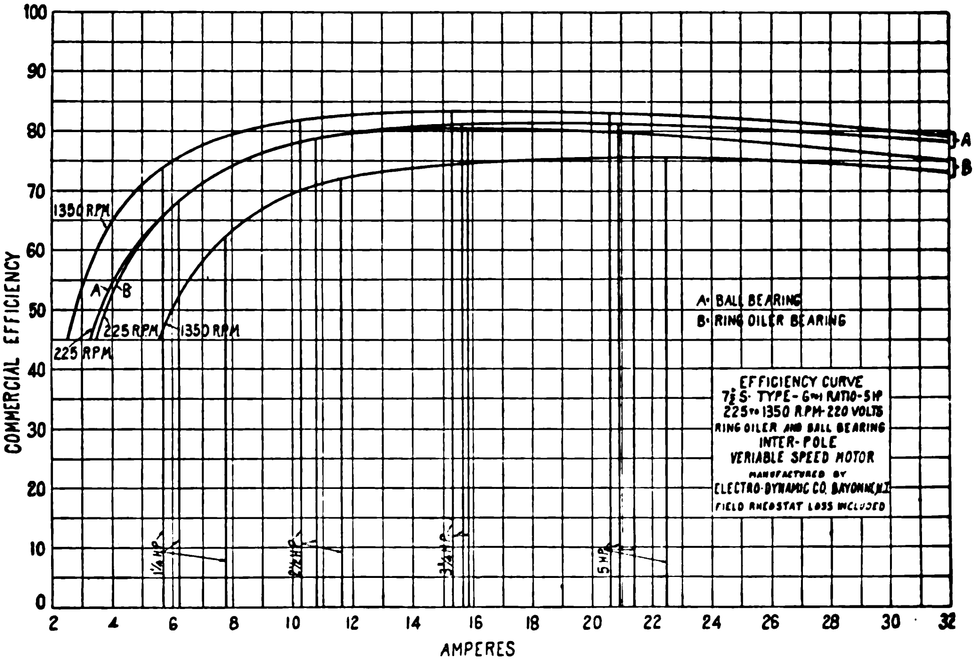


FIG. 20.

races and cones made of special steel, with temper drawn so that they are very tough and will not slip or break. As there are no small journals or pins on the roller an extremely strong bearing is secured. The cone has an especially wide shoulder, against which the ends of the rollers have a bearing practically to the end of the roll, the shoulder having the same degree of bevel as the ends of the rolls, the entire thrust being taken in this manner.

This firm supplied the immense roller thrust bearings used in the electric generators at Niagara. The bearings consist of two steel plates, hardened and ground, with a cage or retainer to carry the rollers, which are also of steel, hardened and ground. The rollers are not tapered or conical, but are made in short sections, so that they turn readily, no trouble being caused by slipping, the design of the bearing taking care of all the outer thrust. It has been found in actual practice that this form of bearing will sustain loads several times the weight that a ball-thrust bearing of the same dimensions will carry, and loads on large generators, rotary converters, &c., ranging from 10,000lb. up to 190,000lb., at speeds ranging from 200r.p.m. to 1200r.p.m., have been carried. Fig. 23 shows the roller-thrust bearing used on a 5500h.p. generator running at 1500r.p.m. at Niagara, which is the largest anti-friction thrust bearing ever made. The rotary weight on the bearing under normal conditions is about 156,000lb., while under extreme conditions of head and tail water levels the load on the thrust may be increased by suction, &c., to a total of 190,000lb. The normal speed is 250r.p.m., but if control is lost of the governor it may reach double that figure. In order to lighten the duties of the thrust bearings of the Niagara generators a balanced piston is fitted in the casing at the bottom of each shaft, and is designed to counterbalance the entire weight of the dynamo shaft and runner. Water is admitted to this piston at about 35lb. per square inch, and can be adjusted by valves as required. If this pressure is removed the entire weight is thrown on the thrust bearing, and this may occur by accident to the valves and piping, or, as frequently occurs in winter, through the water passages becoming clogged with ice. In one of the trials designed to test the bearing under the equivalent of such a condition the roller thrust ran for four hours with full weight on it, and showed absolutely no wear. At the end of a long series of tests the bearing was in perfect condition in all respects.

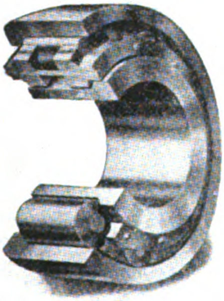


FIG. 21.

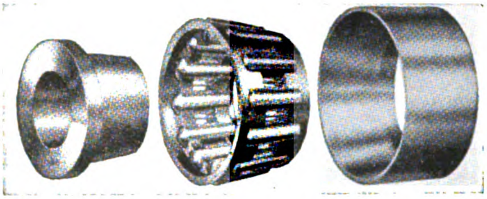


FIG. 22.

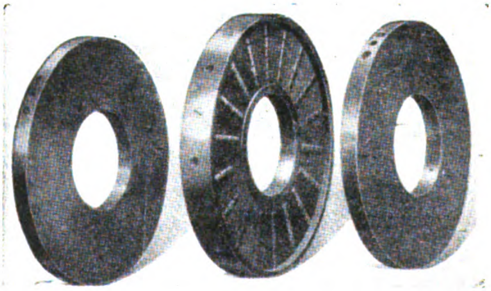


FIG. 23.

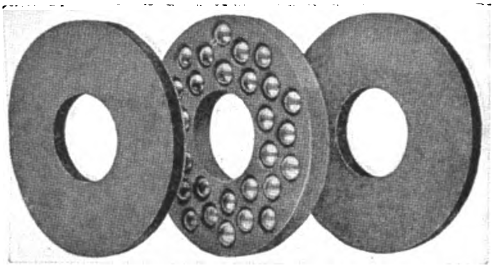


Fig. 24.

With regard to smaller machines, a roller thrust used on a vertical motor made a test run of twenty-four hours with 2750lb. at 750r.p.m. to 760r.p.m. Due to a misunderstanding, it was run absolutely without oil, but the highest temperature reached was 104deg. Fahr. The temperature of the air in the pit where it was located was 96deg., showing only 8deg. rise. For small vertical motors and similar purposes a small thrust bearing is made by this company which can be called one of the most simple thrust bearings ever manufactured. It is shown in Fig. 24. Specially gauged hardened steel balls are held in place in a retaining cage as shown, each piece being complete in itself.

Laurence Scott and Co., Ltd., who make a speciality of ball-bearing vertical spindle motors for pumping plants, recently fitted two such motors in connection with the sewage-pumping plant at Weston-super-Mare, the arrangement of self-aligning ball-journal bearing being shown in Fig. 25. The actual ball races are of Messrs. Hoffman's make, and are arranged to be self-aligning and waterproof. In this installation there are two motors fitted with these bearings driving centrifugal pumps. The sewage is pumped from a receiving chamber into a common suction pipe through suitable valves, and delivered to a sealed main at a higher level. The motors are controlled by a special controller operated by a float in the sewage tank. Similar motors were also installed on the Russian cruiser "Rurik." There were seven motors driving pumps delivering 500 tons of water per hour, and six 17b.h.p. motors driving pumps delivering 300 tons of water per hour, all against 26ft. head. These ball-bearing motor-driven pumps were so successful that a plant is in progress for the city of Norwich in connection with a sewage-pumping scheme.

Messrs. Kynoch, Ltd., have specialised on roller bearings, which they have applied to a large variety of appliances, the bearings being very carefully designed to meet each particular case. For working under certain conditions the rollers are of

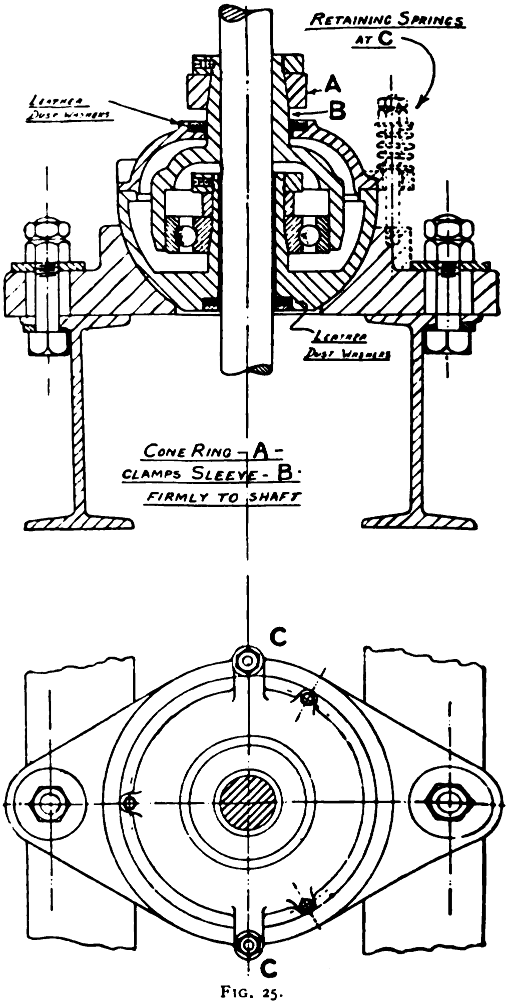


Fig. 25.

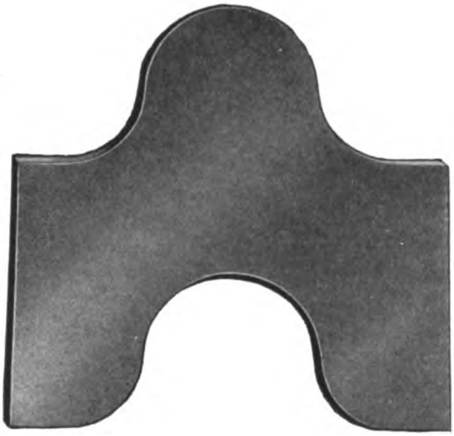


Fig. 26.

solid steel hardened and ground, and carried between hardened steel surfaces held in strong steel cages. A good many other firms make the cages of softer metal in order to reduce friction, but so far as can be ascertained by tests on Kynoch's bearings, no marked difference in result is noticed. Hard rollers are essential under very heavy loads, because if soft metal is used they lengthen under the pressure and become useless. Moreover, the surface on which they run must be hard or else it laminates and peels off. In the bearings used for ordinary line shafting the rollers are formed in a very novel way by rolling a piece of sheet steel of the shape shown in Fig. 26 into a tube, Fig. 27. The object of this arrangement is to cause the fibre or grain of the steel to be always in the direction of rotation. Moreover, such rollers have an amount of elasticity never overcome by the pressure which they have to maintain. They are said to be almost indestructible, in spite of the fact that the rollers are not hardened, and therefore do not laminate the shaft. They are threaded on to steel bars, the ends of which project beyond the rollers and fit into stands cut in the cage, which divides the rollers into separate lines—that is to say, they do not touch either the cage or each other, and thus the friction of rollers against the cage and each other is almost eliminated. By this method the lines of rollers are kept parallel to the shaft, and the risk of foreign matter getting into the bearings and wedging the rollers in the cage is very considerably minimised. The effect of such dirt jambing and wedging the rollers between the bars would be to prevent their turning, and thus forming flats on them and rendering them useless. Fig. 28 shows a Kynoch roller bearing with the top cap removed.

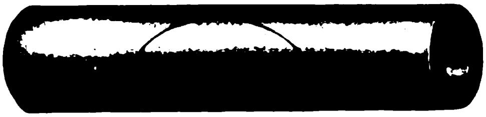


Fig. 27.

From the above survey of the present position of the application of ball and roller bearings to electrical machinery it will be seen that the experimental stage has been passed, and further progress will lie in the direction of familiarising engineers and designers generally with the undoubted economic advantages which the adoption of these bearings will create. When one considers the remarkable strength of the present position, one is tempted to wonder at the conservatism displayed only a few years ago by prominent engineers with regard to the adoption of these bearings, and their attitude can only be explained by the undoubtedly rapid advance which the design of such bearings has made within recent years.

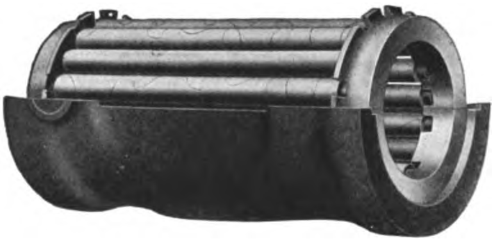


Fig. 28.

ARTESIAN WELLS FOR WORKS.

THE various advantages of well-boring for water do not seem to be thoroughly appreciated or realised by a good many firms in this country, even in this advanced age of 1909. The question of well-boring is often looked at askance, and the firms who carry out this class of work looked upon as folk dabbling in nefarious practices. The people who take this view are generally those who have heard of so-and-so having a firm of borers on his ground, and that they did this, that, or the other, either bored a hole which caved in and brought down a building, or lost a man down the hole, or lost the boring tackle, or found no water after spending an enormous amount. It is a remarkable thing the damage these prattlers can do even among firms who pride themselves on their foresight and keen business proclivities. The writer has met scores of cases in which firms have continued to pay anything up to one shilling per thousand gallons for their corporation water supply (and using scores of thousands of gallons per week) with a magnificent supply of even better water under their feet, simply because they have heard of some case where a firm had spent a large amount of money to get a private supply and had got no return in the shape of water. There may or may not be some truth in this, as it is undoubtedly the fact that there are cases where a bore-hole has been put down and turned out to be what is termed a "dry hole," but does it stand to reason that any bona-fide well-borer who considers his client in any way, or who gives a thought to his future business, will add insult to injury, as it were, by commencing a systematic extortion or "bleeding" in view of the non-success of the job? Is it not more to the borer's advantage to keep any subsequent costs as low as possible in his own interests? There is, however, sad to relate, a certain class of well-borer who rushes blindly in, erects his tackle, and gets to work irrespective of any geological data which might have been obtained or any other information learned by experience. The reason of this blind rush is fear of competition, as he knows full well that should a bona-fide firm be asked to quote his chances of the order are nil. The main argument against the cranks who quote these unsuccessful jobs, however, is to show them the exceedingly small percentage of jobs which really turn out valueless to the firms for whom they have been bored.

The firm with which the writer is connected have bored thousands of yards during the past ten years in all parts of the British Isles, representing hundreds and hundreds of jobs, and not one per cent. of the jobs have proved failures, whilst the successful borings produced quantities of water ranging from five or six thousand gallons per day to as much as a million per day upon a single job.

The question is often put, "Yes, but what kind of water is it when you get it?" Ask the hundreds of breweries who have their own private supplies, or the thousands of mills who use bore-hole water for condensing, in both of which instances temperature is an all-powerful factor. Go to the bleach crofts, calico printers, laundries, &c., where quality of water has to be considered. Go to the various corporations who have hundreds of bore-holes put down. Of course, here again in this instance of quality there are cases where the water has certain detrimental properties, but even then, in these days of water treatment, when we know that hard water, for example, can be treated for less than one penny per thousand gallons, need that frighten one?

As a despairing kick, and as usual where new business is proposed, there are the firms who point out the initial expense, but fortunately these cases are only few. Where is the reason, for instance, in a man who is paying £300 per year for his water stating that £600 is too much for him to pay to obtain a larger quantity of better water than he is buying, and ultimately (confusion worse confounded) offering to give the order for the boring work on condition that he pays for the job quarterly (after it is completed and he is getting his supply) with his water rent? Truly the munificence of some men is astounding.

To summarise the whole matter, the question a firm should ask is:—Do we use enough water to make it worth our while to obtain our own supply, or do we pay so little for it as not to merit the initial expense of obtaining such supply? Once this question is satisfactorily answered and the resolve made to have a private supply, send for a bona-fide well-borer (and there are plenty of them), and take his advice as to what is best to be done. He will not advise his client to do anything likely to affect his good name in any way, as a borer's good name is a very valuable asset, which once acquired is not readily parted with. Also always bear in mind that it is not fair to expect the initial cost of the boring, &c., to be paid for out of, say, a couple of years' water rents. A fair way of summing up would be for, say, a 10,000 to 12,000 gallon job as follows: Put down the expense of bore-hole and pump at £800; then—

5 per cent. charged by Bank on this amount ..	£ 40
20 per cent. of value of job	160
Running expense, say, 1d.* per 1000 galls. = 60/- per week	156
Total	£356

* This figure is a very large one.

Set this in the debit column of your private water supply, and in your credit column set down what you paid for the quantity of water bought in the year when you were on a public supply, which at 12,000 gallons per hour runs out to over thirty millions per year at, say, £25 per million (equals 6d. per 1000). Your bore-hole stands as a good investment, and your well-borer as a proud man.

The next year you would deduct £160 from the £800, equals £640, and charge bank interest on this, taking off also a further fifth of the cost of the job. Thus in five years the bore-hole has paid its own interest on its mortgage, redeemed the mortgage one-fifth annually, paid for its own running and upkeep, and then shown a really handsome balance in its favour. This instance is not a paper one, but is what is happening every day in hundreds of cases, and it is only when these instances become better known and more widely spread that we shall hear of the emancipation of the well-borer.

Ernest Snelson.

HIGH-SPEED STEEL TOOLS.

THE importance of utilising to the full the advantages of modern high-speed steels for tools in engineering manufacture cannot be gainsaid. The preparation of the tools, their form, temper, class of duty, attention, etc., are facts to be kept ever in sight as having a very appreciable effect on works production costs. Consequently, it has become absolutely necessary for full records to be systematically made of the trials and errors of experience in this branch of work—for it is only by repeated trials that the best tool for any particular service is developed. A writer in "Machinery," in the course of an article dealing generally with this subject, reproduces a record card embodying those facts which it is desirable to keep for permanent reference, and also an instruction card which serves as a guide to the tool-maker, indicating the material, method of working, and the technical details which are to be observed and recorded in connection with the making of the tool. These printed cards or records are respectively as follows :—

TOOL RECORD.

Tool Name ....Size ....No.....Lot No.....
For Piece No.......Operation No.......Department........

Steel ....Analysis: C..T..Cr..Mo..
Critical Point ....   S..Si..V.. ....
C. P. Determined ....Analysis Determined ......

Forging Temperature ....Forge No.......Smith......
Hardening Temperature........Furnace No. ..Operator....
Tempering Temperature ......Furnace No. ..Operator....
Ground before Hardening? ....Finish Grinding by ....
Date Finished ....Checked by ....

Memoranda..
....
....
....
....
(Signed)

DIRECTIONS TO TOOL-MAKERS.

1. Lot No. ....
2. Kind of Tools ....
3. Steel to be Used ....
4. Class of Work on which Used..........................

5. Hardening Furnace ....
6. Temperature.......................................
7. Method of Cooling ....
....
8. Temperature of Bath...............................

9. Method of Tempering ....
10. Tempering Furnace ....
11. Temperature.......................................

12. Memoranda ....
....
....

Completed ....
(Signed)

Naturally a full record is also made of the behaviour or performance in the shops of each particular tool; and thus, by systematic modifications in the making of further tools for the same service, the records will indicate the best possible tool and provide sufficient and accurate data to ensure the duplication to any desired extent of this best result. It will be seen that this systematic method of gaining the full advantage of the steel used calls for great accuracy of work and observation on the part of the tool-maker, and, indeed, involves the institution of an experimental tool department, properly equipped with appliances which will ensure absolute duplication of process and accurate indications of the technical figures required.

There are several properties which enter into the making of the most efficient tools. It used to be almost entirely a matter of the degree of hardness which the tool-maker could secure—that is to say, the harder the tool the better. Practice with high-speed steels shows, however, that in some cases it is better to run with tools that are not tempered to extreme hardness.

As to the size of stock to be used for tools and the allowances to be made for mechanical reductions in finishing and grinding after hardening, this depends naturally upon the form and size of the tool. In the case of tools for lathe and planer service the size of stock is limited by the point at which sufficient section is given to ensure rigidity of the tool under the heavy cutting stresses. With drills and milling-cutters allowances require to be made for dressing the tool after hardening. In small tools this allowance is considerable; with tools of larger section the proportional allowance is, of course, less. Tools of about one-inch thickness should be given about one-eighth of an inch margin.

Shrinkage during the hardening process is almost invariably the result of exposure to the air while the tool is very hot. The loss due to actual shrinkage is so small, except in large tools, as to be scarcely appreciable, and is usually negligible when the barium chloride process is used. If the hardening is done by the customary methods, a slight allowance is possibly desirable in certain cases, say in the arbor holes in milling-cutters, the diameter of taps, &c. With care in hardening, even by the customary processes, the variation in a 1in. diameter will scarcely exceed 0.0005in., and more likely will be less, though, indeed, it may be as great as 0.001in. and even more—so much depends upon the care exercised and the method employed. It need scarcely be added that the holes in all milling-cutters intended for very accurate work should be ground after hardening, the tools having been first carefully centred in a chuck.

It might also be mentioned that apparent variations in the size of tools like dies and taps and other tools which cannot be ground after hardening are frequently only the effects of the roughening of the surface during the treatment. The barium process very largely overcomes this difficulty, and does so entirely unless, as is generally the case, the defect is present before the hardening. This roughness usually arises from the method of cutting the threads or teeth, as the case may be. Such threads or teeth are best, and, of course, most quickly, cut by milling, lubricating the cutter with thin oil. Next to this it is best to rough out the threads with a chaser, as close to size as may be, without lubricant, and then to re-cut or finish with a single-point tool held in a spring-thread holder, the threads being kept slightly lubricated with very thin oil.

To compensate for the roughness often present in high-speed tools of this class, it is customary to give rather more relief than in the case of those made of ordinary steel. The increased relief minimises the lodging of particles of steel in the surface of the cutter behind the cutting edge, which tend to act as cutters, sometimes very appreciably in-ceasing the cut.

Extreme smoothness is also a desirable quality in high-speed drills, but it seems impossible to obtain by present methods of cutting a smoothness of surface like that of the carbon steel drills; to secure this it is necessary to polish the flutes. If the hardening is by the barium process, the polishing may be done before hardening, for that process leaves the surface absolutely unimpaired.

The early method of economising in steel by using tool-holder stock rather than making the entire tool of high-speed steel in the case of those tools whose cutting edges or points work without intermission (as those used for turning, planing, and similar operations) is open to criticism, and is not now so general. A characteristic of the operation of high-speed tools is the rapid generation of heat in the cutting edge. In the case of milling-cutters and kindred tools this is of small consequence, because the cutters are intimately attached to a relatively large mass of metal which rapidly conducts the heat away. Furthermore, these cutters work intermittently, each for a very brief space of time, and for the remainder of the revolution are exposed to the air and cooled by it. The cutting edges do not, therefore, get exceedingly hot, as is the case with the edge of a turning tool run at the same speed. It is necessary that the body of such a turning (or similar) tool be large enough to conduct away a considerable portion of the heat generated, and in order to do this effectively the tool must be continuous; that is, there must be no appreciable separation between the part of the tool which does the cutting and the body from which most of the heat radiates, as there is ordinarily when a small piece of steel is held in a tool-holder. There are, indeed, tool-holders which minimise this difficulty; but even these are not satisfactory in large sizes. From the first, methods were sought whereby high-speed steel cutting points could be intimately combined with tool bodies of ordinary and much cheaper steels. For the most part the methods tried were ineffective and impracticable. The reasons are not well understood. The disinclination of the two steels to unite probably is due to a difference in their coefficients of expansion. There is, however, no trouble in brazing them together; and when this does not involve placing a great strain upon the brazed joint this method does very well. Obviously the cutters are hardened before being brazed into place. A successful example of such a combination is a lathe or a planer tool made with practically no forging and with a relatively thin plate of high-speed steel brazed to the front and top to form the cutting edge. Rose and other forms of reamers and mills have been made in a similar way, the body of machinery steel being machined with recesses for high-speed blades, which are brazed into place. Such tools have been in use for several years with satisfaction. The latter, especially, are as good as if of solid high-speed steel except when it is essential that they be re-annealed or re-hardened—which is seldom necessary.

The electric welding of a high-speed cutting point to a machinery steel tool body, the latter of such proportions, of course, as to give the requisite strength to the tool, has proved satisfactory. Such tools conform to the requirement of being perfectly continuous, and the weld is practically as strong as the rest of the tool. It is feasible to forge the end to any required shape as if the entire tool were of high-speed steel; and, since in hardening only the nose is heated to a high heat, the machinery or tool steel body is in nowise impaired. The method of electrical welding, as used in this connection, is exceedingly simple. The two pieces to be welded are attached to the terminals of a circuit of suitable voltage and the edges brought together. The resistance to the passage of the current offered by the imperfect contact sets up enough heat to melt the metal and forms a perfectly homogeneous junction. The autogenous (oxygen and acetylene blow-pipe) method of welding is almost as simple; the flame is directed into the crevice where the two pieces are brought together and melts the adjacent metal so as also to form a homogeneous joint.

Another method recently brought forward, somewhat resembling brazing, is asserted to give a joint fully as strong as the rest of the tool. A thin film of copper is placed along the line of the joint, and the parts to be welded are surrounded by a reducing compound and then placed in a furnace raised to a temperature of about 1200deg. C. (2200deg. F.). The copper flows freely into the interstices, and is said to produce actual cohesion between the adjacent molecules, making a perfect joint, so strong that a fracture will follow a new break rather than pass through the joint.

These methods are available for all classes of tools made partly of high-speed and partly of machinery steel or other materials, and are available also for the repair of broken tools, many of which can thus be saved for further use. The repairing may involve the welding of the broken parts or the replacing of an old part by a new, as may be most expedient.

Only an expert can nick and break high-speed steel from the bar without damage to the structure adjacent to the fracture—and even an expert cannot be sure of doing so with safety; the best way, where the end is to be used for working purposes, is to cut the bar. The circular saw most frequently used does very well, though a band saw works better and rather more rapidly. Small bars can readily be cut in bundles, if held very rigidly. The saws, obviously, should themselves be of high-speed steel. A most effective method has recently been employed for cutting these steels by means of a highly-speeded disc of tough steel. When an unused disc is first forced against the high-speed steel it does not take hold well; but after being run in contact with the high-speed steel for a time it cuts perfectly and rapidly, leaving a clean burless kerf. The disc may be of any steel tough enough to withstand the tremendous centrifugal (and other) stresses set up by the pressure of the disc against the work and the extremely high speed required. Just why such a disc cuts is not exactly clear; the periphery is usually found studded with particles of the steel being cut, and the "sawdust" appears to be the result of true cutting.

Fine cracks in tools are most difficult to discover. Even the microscope often fails to disclose them. Generally they can be detected, if present, by the very simple expedient of moistening the suspected surface with petroleum, rubbing clean, and then wiping off with chalk. Some petroleum enters the cracks and afterwards sweats out, moistening the overlying chalk. The nature and extent of the cracks are thus rendered visible. This frequently is of great importance in testing lots of high-speed steel tools.

Tools which have worn down so as to be useless can usually, when made of solid high-speed steel, be forged or machined down and worked into tools of smaller size if ordinary care is exercised. It is necessary always to re-anneal prior to attempting to machine such old tools; and it is also expedient when forging them to smaller shapes. In passing, it might be mentioned that re-annealing is desirable after machining and before hardening all sorts of intricately-shaped tools, in order to relieve any possible machine-caused strains. In re-forging high-speed tools it is desirable that they be heated rather slowly at first; they should not be thrust cold into a very hot fire.

* * *

THE ELECTRIC SHAFT FURNACE AT DOMNARFVET, SWEDEN.

THE following particulars of the construction and performance of the electric furnace recently erected in Sweden for the smelting of iron ore on a commercial scale by electricity form the subject of an official report by Dr. Eugene Haanel, the Director of Mines to the Canadian Government.

In the winter of 1905-6 a series of experiments in electric smelting were conducted at Saulte Ste. Marie, Ontario, under the auspices of the Dominion Government, with the object of establishing the feasibility of economically smelting Canadian magnetic iron ores comparatively high in sulphur, but free from manganese, and using charcoal as the reducing agent.

As a result of these experiments, the electro-metallurgy of the reduction of refractory iron ores without the use of coal or coke fuel was established, and—as far as could be expected from a small, experimental furnace—the output of pig iron per electrical horse-power-year determined. Moreover, based upon the experience thus gained, certain fundamental changes and improvements, necessary in the construction of an economic electric furnace in the future, were suggested, in order to render it suitable for the production of pig iron on a commercial scale.

In Sweden, where the conditions governing the economical use of the raw materials necessary for an iron industry are very similar to, and in many respects identical with, those existing in several of the provinces of the Dominion of Canada, the importance of an economic commercial electric smelting process was fully realised by three young Swedish engineers some two years ago. These engineers: viz., Assar Grönwall, Axel Lindblad, and Otto Stalhane—stimulated by the successful results of the work done at Sault Ste. Marie—undertook to solve the problem of designing and constructing a commercial electric furnace.

Inasmuch as the electro-metallurgy of the reduction of iron ores had been established by the Canadian experiments, these Swedish inventors concentrated their entire efforts in an attempt to solve the practical commercial problem along the lines suggested. In carrying out their plans to a successful issue they were ably assisted by the ironmasters of Sweden, who manifested great interest in this question. Special assistance was rendered by the able and far-sighted director, E. J. Ljungberg, and the vice-director, Lars Yngström, of the largest and most influential industrial company in Sweden: the "Stora Kopparbergs Bergslags Aktiebolag." The inventors made an agreement with this company and the "Trafikaktiebolaget Grangesberg—Oxelösund" (owners of the largest iron ore deposits in Sweden) to carry on smelting experiments on a large scale at the Domnarfvet iron works. In order to concentrate their undivided attention on this problem, the inventors formed a company called the "Aktiebolaget Electrometall," to which the patent rights were assigned.

The construction of the specially-designed electrical machinery and the preliminary work necessary for the construction of the furnace were commenced in April, 1906; and towards the end of that year—when the installation of the electrical machinery and high-tension cables, &c., was completed—the construction of the first electric shaft furnace was begun.

This furnace was put in operation April, 1907, and from that time experiments were continuously carried on and improvements made, the daily experience thus gained being utilised in successive changes in design and reconstruction towards perfection.

All experimentation was conducted along scientific lines, and has yielded a rich fund of useable knowledge and instructive data as follows: (1) on the construction and operation of electric furnaces; (2) on the conductivity and other characteristics exhibited by materials when subjected to high temperature; (3) on the qualities of the refractory lining materials; and (4) on the most suitable manner of designing and constructing the masonry of the furnaces. In addition to this, different methods of supplying the current and various contact devices, &c., were tried and tested. In these initial steps the experimenters did not confine their entire attention to the practical side of electric smelting, but carried on laborious researches and investigations concerning the solution of purely theoretical problems; and the determinations made and data gathered will doubtless form an important contribution to the electro-metallurgy of iron and steel.

With a view of elucidating a number of disputed technical points involved in the smelting process itself, initial experiments were conducted at Ludvika during the summer of 1907 with a small furnace of 300 horse-power capacity. During these preliminary experiments many difficulties were encountered which had to be overcome; and it was not until the summer of 1908 that they succeeded in designing and constructing a furnace which, in their opinion, could be economically used in practice. Towards the end of the summer a number of experiments were made with this furnace, which demonstrated that the type evolved was durable, and that a good output could be obtained therefrom; notwithstanding the fact that the furnace was constructed with a relatively low shaft in order to reduce the building expense. On account of this low shaft, which was open at the top—as in the case of the furnace employed at Sault Ste. Marie—the consumption of charcoal was large: viz., 460 kilograms per metric ton of pig iron produced. A considerable portion of this charcoal was consumed at the top of the open shaft, and the gas escaping from the furnace consisted almost wholly of carbon monoxide. Hence, notwithstanding the excellent results obtained with this furnace, the inventors conceived that by utilising the waste gases even more economic results could be attained, and consequently decided to construct a new one of larger capacity, with a higher and more rationally designed shaft.

This new furnace was completed early in December, 1908, and the intention was to at once begin an extended trial run; but owing to a severe drought—such as had not been known in Sweden for generations—this extended trial had to be postponed. Some time previous to the completion of this furnace the inventors tendered the author an invitation to witness a short trial test to take place early in December. As a concession to Mr. Haanel, who had visited Sweden for the purpose of the tests and inspection, Mr. Ljungberg, the general director of Stora Kopperbergs Bergslags Aktiebolaget—at whose works the furnace was erected—very generously allowed the use of power to operate the furnace for twelve days. This concession, which entailed considerable inconvenience in the general operations of the steel plant, shows the great importance attached to the solution of this metallurgical problem by men competent to judge.

The inventors, however, stated that they did not expect entirely satisfactory results as regards the output of pig iron per electrical horse-power year, since a furnace of this size could not possibly arrive at its normal working condition in the short time allowed for the test, inasmuch as the walls are so thick that it takes a comparatively long time to heat them entirely through, and acceleration of the heating could only be accomplished at the risk of damaging the furnace walls. In addition to this, the shaft should not be filled to the top until after several days' working. The experimental trials were not conducted for the purpose of determining the output of pig iron per electrical horse-power year—this had been satisfactorily determined by the experiments at Sault Ste. Marie, as well as by the Swedish inventors in their experiments with the furnace preceding the one investigated at Domnarfvet—but to demonstrate the commercial feasibility of the furnace, and to prove whether uniform working without disturbance could be expected.

Description of the Electric Plant.

The experimental plant (Fig. 1) was installed in an old building adjoining the basic Bessemer converter house.

The machinery, which was specially designed and constructed for the experimental trials, consists of a three-phase synchronous motor of about 900 horse-power, supplied with a current of 7000 volts, and 60 periods, from a three-phase cable line in the iron works. This motor is directly coupled to a three-phase generator, which supplies current of 25 periods, adjustable to between 300 and 1200 volts, through small intervals to the transformers erected in the immediate vicinity of the furnace.

By means of this extensive regulation it is possible to determine the most suitable voltage to be employed with furnaces of different construction and operating under various conditions.

The fields of both the synchronous motor and the generator are fed with current at a

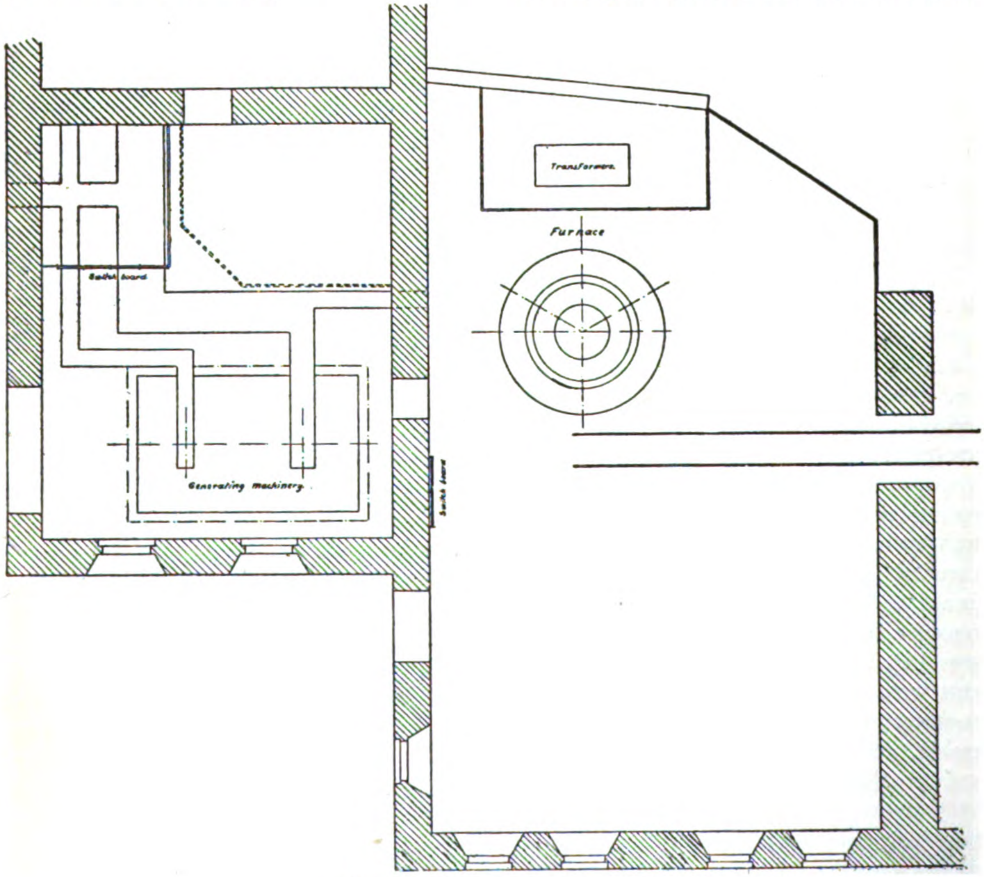


FIG. 1. PLAN OF SMELTING PLANT.

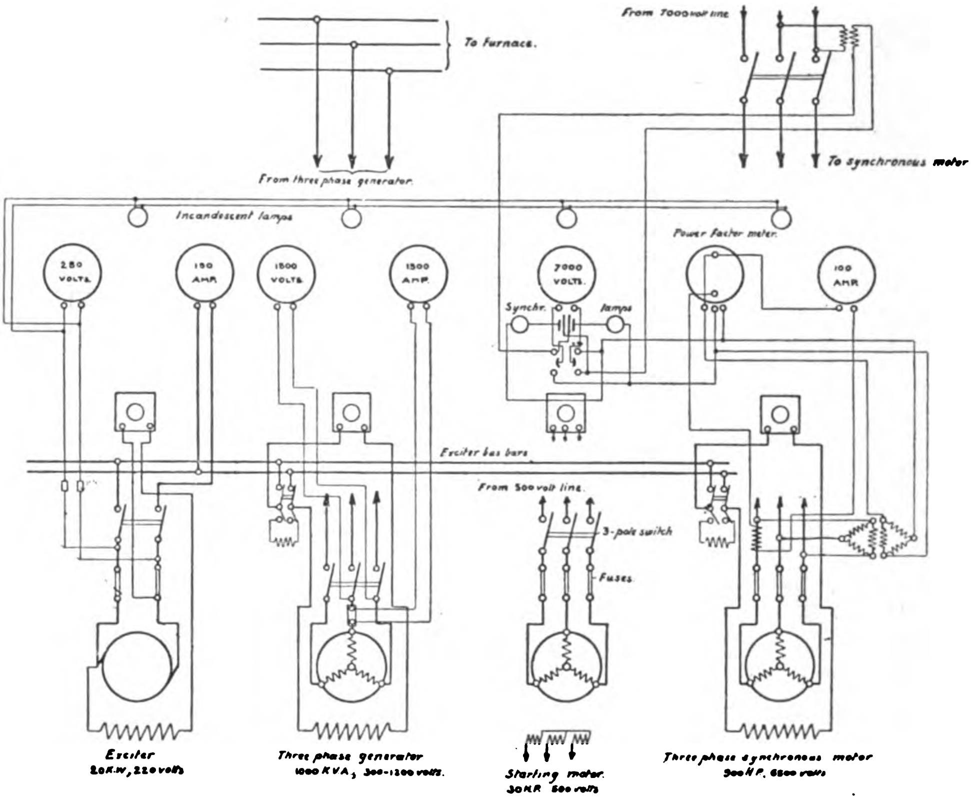


FIG. 2. DIAGRAM OF SWITCHBOARD CONNECTIONS IN POWER HOUSE.

tension of 220 volts, from a direct current generator, 20kw. capacity, directly coupled to the system. For starting the system a three-phase synchronous motor, directly coupled, is employed. This is fed with a current stepped down to 500 volts. The arrangement for controlling the machines may be seen from the coupling scheme shown in Fig. 2.

From the switchboard the current is conducted, through copper bars laid in cement channels, to the three-phase transformers. The capacity of these transformers is 1500 k.v.a. and their ratio of transformation 14:1. By regulating the tension of the generator the low tension sides of the transformers can be altered through small intervals from 20 to 85 volts. The ratio of transformation can be altered to 7:1 by means of certain easily-performed changes of coupling in the transformers, in which case the low tension can be varied between 40 and 170 volts. The transformers are cooled with air supplied under pressure by two electric blowers.

A switchboard is situated conveniently near the furnace for controlling its operation, on which are mounted the following instruments: one three-phase precision wattmeter for differently loaded phases; three ammeters, one for each phase; and one voltmeter.

The ammeters and the wattmeter are connected to the current system by means of transformers. The voltmeter and tension terminals of the wattmeter are directly connected to two of the conducting bars.

To protect these instruments from heat when tapping, an iron curtain which may be lowered or raised, is placed in front of

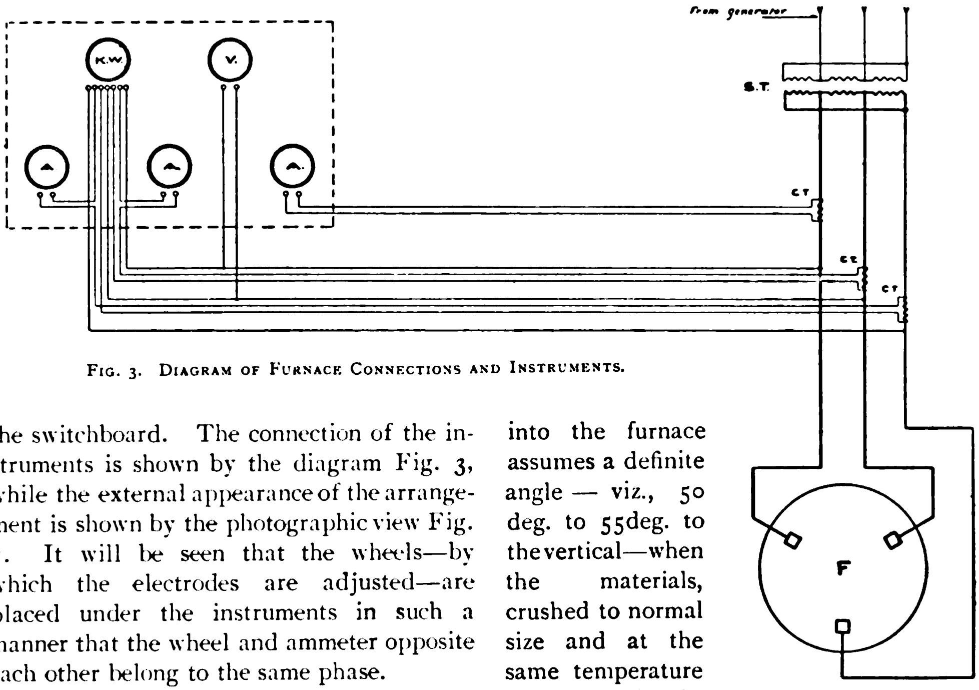


Fig. 3. Diagram of Furnace Connections and Instruments.

the switchboard. The connection of the instruments is shown by the diagram Fig. 3, while the external appearance of the arrangement is shown by the photographic view Fig. 7. It will be seen that the wheels—by which the electrodes are adjusted—are placed under the instruments in such a manner that the wheel and ammeter opposite each other belong to the same phase.

Description of Electric Shaft Furnace.

In general appearance the electric shaft furnace is unlike any hitherto constructed, being very similar in design to an ordinary blast furnace in which the tuyères are replaced by electrodes.

A vertical section of the furnace is represented by Fig. 4, and Fig. 5 shows a top view with the shaft and electrodes removed. The height of the furnace above ground level is about 25ft. The melting chamber or crucible containing the electrodes is about 7ft. high, and is of greater diameter than any other part. The shaft is about 18ft. high, the lower end of which—for about 4ft.—has the form of a truncated cone for the purpose of directing the charge into the crucible in such a manner that the electrodes, lining, and descending charge could not come in contact. This special feature in the design was introduced by the inventors after repeated experiments, which demonstrated that the upper surface of the column formed by the materials charged into the furnace assumes a definite angle — viz., 50 deg. to 55deg. to the vertical—when the materials, crushed to normal size and at the same temperature as that existing in the melting chamber, are allowed to fall through a circular aperture into a free space. In Fig. 4 the slope is indicated by dotted lines.

It is this isolation of the descending charge from the lining at the point where the electrode enters the furnace that constitutes the particular economic advantage of the construction, since it prevents the destruction of the lining, which occurred in all previous furnaces where the electrode came directly in contact with the melting charge and the lining; for the temperature of the brickwork in close proximity to the electrodes becomes so great that the most refractory lining materials are rapidly destroyed even when the electrodes are cooled by water jackets.

The contracted neck of the shaft immediately over the central opening into the melting chamber is not supported by the arched roof, but the entire weight of the shaft is carried by six cast-iron columns arranged symmetrically around the furnace hearth.

The melting chamber is made in the form of a crucible, and is covered with an arched roof provided with openings for the reception of the electrodes and descending charge. The roof and walls of the crucible are lined with magnesite.

For the purpose of cooling the brickwork composing the lining of the roof of the melting chamber and thereby increasing its life, three tuyères are introduced into the crucible—just above the melting zone—through which the comparatively cool, tunnel-head gases* are forced against the lining of the roof into the free spaces. This gas absorbs heat from the exposed lining of the roof and walls and the free surface of the spreading charge, thus effectively lowering the temperature of the roof and exposed walls.

With the exception, however, of radiation from the tuyères, no heat is lost by this method of cooling or lowering of temperature since the heat given up by the lining of roof and wall to the comparatively cool gas introduced through the tuyères is imparted in passing upward through the shaft to the cooler portions of the descending charge. This effects not only a better utilisation of the reducing power of the CO, but in addition produces a better distribution of heat throughout the charge in the shaft than in any electric furnaces previously constructed.

The tuyères are provided with sight holes, covered with mica, through which the interior surface of the arched roof can be observed. By means of this device it is possible to determine approximately the necessary quantity of gas required to effectively cool the roof lining at the mouth of the melting chamber.

Each electrode was built up from two carbons 11in. square by 63in. long, making the total cross section of the built up electrode 11in. by 22in. The electrode holder is made of a strong steel frame, forming a support for the wedges, by means of which the copper plates conducting the current from the copper cables are pressed against the faces of the electrode.

The electrode is clamped in the steel frame mentioned above, and slides on two guides, which serve the two-fold purpose of keeping the angle of inclination to the vertical constant, and relieving the arched roof of any undue strain which would arise from the weight of the electrode if insufficiently supported. A steel cable, secured to the top of the electrode holder and passing over a system of guide wheels or pulleys to the drum operated by the hand wheel on the switchboard, serves to lower and raise the electrode, by winding or unwinding the drum.

In order to protect the parts of the electrodes outside the furnace from the oxidising action of the air, a suitable covering is provided.

The water-cooled stuffing boxes, through which the electrodes enter the melting chamber, are provided with special devices (not shown on the drawing) for preventing the gas under pressure within the melting chamber from leaking out around the electrodes.

The shaft—as previously mentioned—is supported by an iron plate, resting on six cast-iron pillars arranged symmetrically around the furnace hearth. To prevent the pillars from being cut off in the event of the molten iron accidentally finding its way to them, the lower parts are protected by sand enclosed in a sheet-iron casing.

This mode of construction enables the operator to repair or replace without removing the shaft those parts of the furnace needing the most frequent repairs, viz., the lower part of the shaft and the melting chamber.

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* During the run of the furnace now in progress (July 7), an examination of the tunnel-head gases was made resulting as under:—

The escaping gases were kept (by regulating the circulation) at a temperature of 200 deg. to 300 deg.; and the following is an analysis when using—

Hematite:		Magnetite:	
CO_2	40 per cent.	CO_2	25 per cent.
CO	50 ,,	CO	65 ,,
H	10 ,,	H	10 ,,

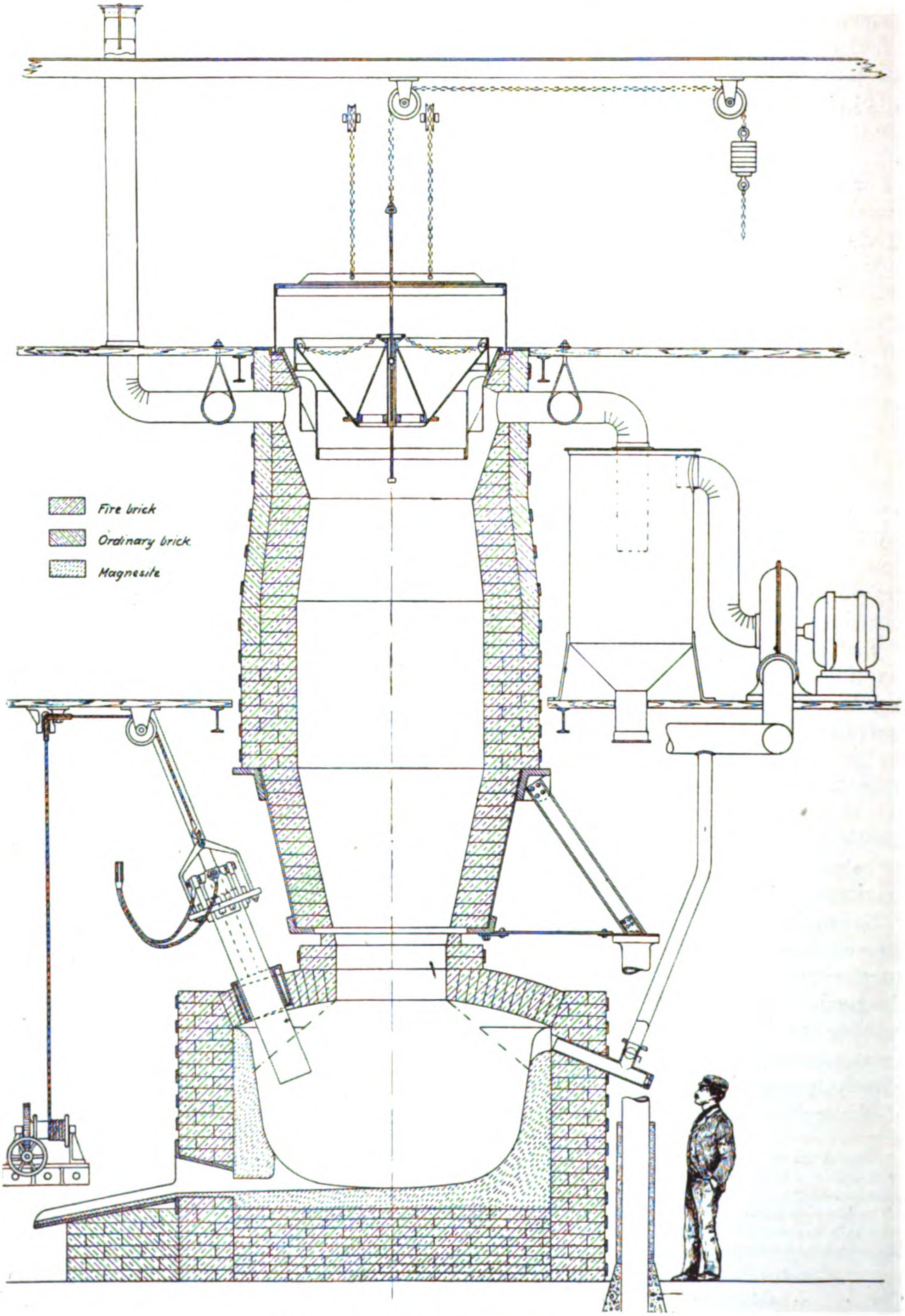

Fig. 4. Sectional Elevation of Furnace.

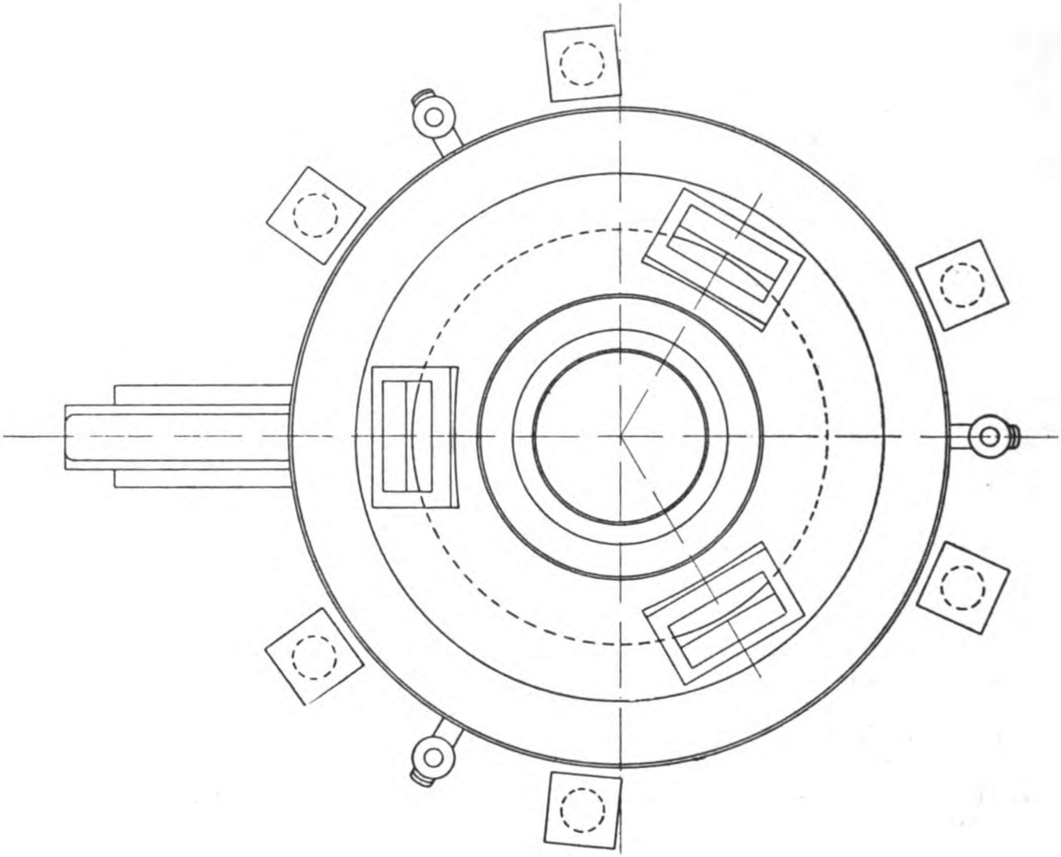

FIG. 5. PLAN OF FURNACE.

In order to collect the waste gases at the throat of the furnace—with the object of utilising them economically and at the same time to protect the charcoal fuel from premature combustion—the top of the shaft is closed by an iron cover, fitted with a charging bell and hopper, covered in by means of a specially constructed sheet iron hood, designed to prevent gas explosions caused by the intrusion of atmospheric air into the shaft when a charge is being introduced.

The collected gases at the throat of the furnace are discharged into a downcomer pipe, provided with a dust-catcher, from which the gases, largely denuded of dust, are drawn by means of a fan, and forced down into the melting chamber through the three tuyères.

With a view of preventing excessive pressure in the interior of the furnace, an uptake pipe, provided with loaded, self-closing valve, is placed at the junction of outlet pipe and top of downcomer, for conducting the gases generated in the furnace (when the pressure reaches a certain point) to apparatus designed for the utilization of the waste gases or to the atmosphere.

Raw Materials Used.

The iron ore placed at the disposal of the inventors for the trial run was magnetite from Grängesberg, and had the following composition :—

	Per cent.
Fe_3O_4	66.46
Fe_2O_3	21.21
MnO	0.30
MgO	0.98
CaO	3.84
Al_2O_3	1.07
SiO_2	3.16
P_2O_5	2.34
S	undetermined
Metallic iron	62.96

During the first part of the trial run, coke containing 85 per cent. C and 0.55 per cent. S was used. This, however, had been exposed for a long time to the open air and rain, which made its percentage of moisture unusually high. Lime was used as a flux.

The raw material, crushed to pieces of about 1in. diameter, was conveyed to the charging floor of the furnace, where it was weighed, and charged by hand. The instruments were read every half-hour, the product of each tapping carefully weighed, and samples of both the iron and slag taken for analysis. The iron and slag were tapped through the same hole, but no difficulty was encountered in separating the iron from the slag after cooling.

The men operating the furnace were divided into two shifts, each shift being of twelve hours' duration, and consisting of four labourers and a foreman.

Heating of the Furnace.

Notwithstanding the fact that the furnace was new in every respect, only one week was allowed for heating from the time the first coke fire was lighted in the melting chamber to the time of the first tapping. Experience with blast furnaces has proved that at least three weeks should be devoted to the drying of the linings in furnaces of this size prior to charging; otherwise the heat energy which should be utilized in the reduction and dissociation of the ores will be expended in converting the moisture in the brickwork into steam, resulting in the chilling of the iron and consequent reduction of the output. The unavoidable neglect of this precaution in the present instance interfered materially with the normal thermal working condition of the furnace throughout the entire trial, especially at the beginning, as the output clearly showed.

Power Supplied to the Furnace.

Although the furnace was designed for a much larger capacity, the power available at this time was only 400 to 450 kw. The tension was kept at between 40 and 50 volts, and the power factor—which, with the lower tension during the first part of the run was 0.85—rose to 0.90 with the higher tension.

A point in the construction of this furnace deserving of special mention is the almost complete absence of fluctuation in the instruments for recording the current and tension delivered. This, in former electric furnaces, occasioned a serious difficulty, and necessitated either the installation of automatic electrode regulators or the constant presence of a man at the switchboard for adjustment and regulation. In this case, however, the only regulation required is that corresponding to the consumption of the electrodes, which requires to be done once a day, and sometimes for slightly longer periods. The cost of the electric installation for this furnace compared with that of other types is, therefore, cheaper, inasmuch as the costly apparatus for controlling the electrodes is dispensed with. Since the fluctuation of power is almost negligible, and current shocks do not have to be taken into consideration, this type of electric furnace constitutes an ideal load for a power station.

The Trial Run.

The trial run was started at 6.30 a.m., December 27, when the readings of the different measuring instruments were taken and recorded every half-hour. Samples of the pig iron and slag were taken for analysis, and the iron—after the slag had been entirely removed—carefully weighed.

During the first part of the trial the composition of the charge was :—

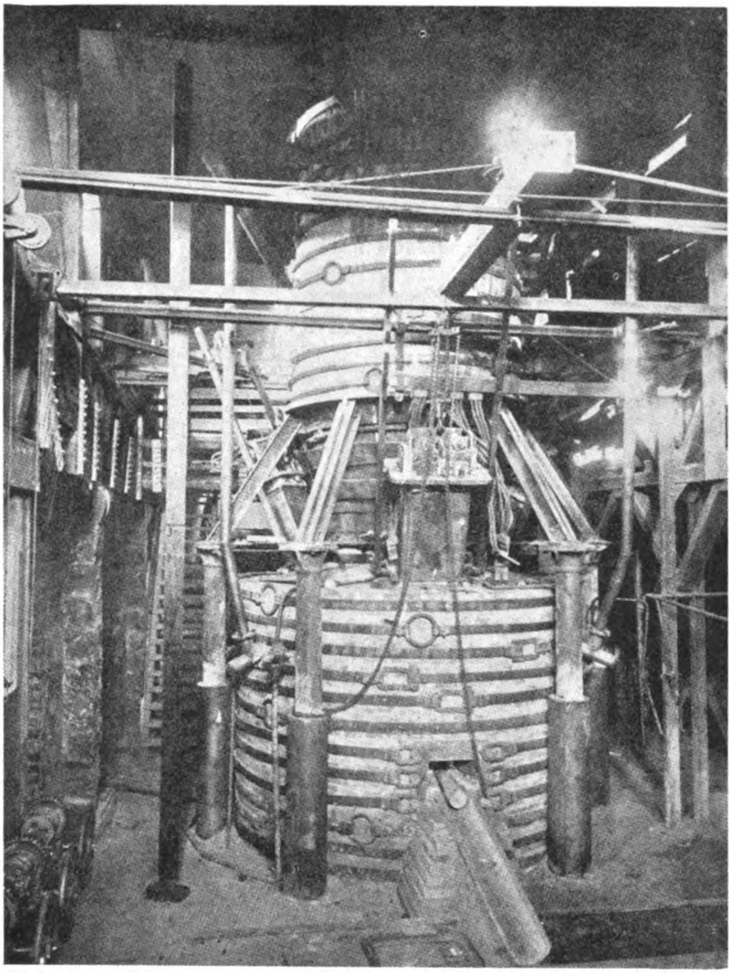

Fig. 6. General View of Furnace.

Ore	209.0lb.
Coke	48.4lb.
Lime	11.0lb.

The coke used in this charge corresponds to a consumption of about 810lb. per long ton of pig iron. During tapping, however, carbon was observed to escape through the tap-hole with the slag, which, in addition, contained a considerable amount of carbide. This indicated an excess of carbon. The charge was, therefore, altered the next morning to the following composition :—

Ore	209.0lb.
Coke	42.0lb.
Lime	4.4lb.

corresponding to a consumption of carbon of about 704lb. per long ton of pig iron.

On the evening of the same day the charge was again changed to :—

Ore	220.0lb.
Coke	41.8lb.
Lime	4.4lb.

which corresponds to a consumption of carbon of about 671lb. per long ton of pig iron.

The coke used up to this time was very wet, having been exposed to rain and snow. As, however, dry coke, which consequently contained a higher percentage of carbon per unit weight, was now available, the charge was again changed to :—

Ore	220.0lb.
Coke	37.4lb.
Lime	4.4lb.

which corresponds to a consumption of coke of about 605lb. per ton of pig iron. This might be further reduced when the furnace is working normally and the gases circulated as previously described. However, this consumption of carbon must be considered as extremely satisfactory.

Analyses of the pig iron from six different tappings and of the slag from tapping No. 4 are given below. From an inspection of these analyses it will be seen that the sulphur content, especially in the last one, is exceedingly low. During the last tapping the temperature of the furnace was higher than in the former tappings, which accounts for the low sulphur content.

ANALYSES OF PIG IRON PRODUCED.

Cast No.	C	Si	Mn	P	S
2	3.20	0.056	0.32	1.80	0.015
3	3.20	0.103	0.37	1.50	[1] ....
4	3.40	0.065	0.34	1.64	0.015
5	3.20	0.075	0.32	1.80	[1] ....
9	3.20	0.075	0.39	1.90	0.015
13	3.15	0.070	0.24	2.06	0.005

[1] Undetermined.

ANALYSIS OF SLAG FROM CAST NO. 4.

SiO_2	26.54
CaO	54.48
S	0.78
Fe	0.35

It may be pointed out that the output continued to steadily rise as the furnace more nearly approached its normal working condition, even with the inadequate power supplied, until an unfortunate accident occurred to one of the water-cooled stuffing boxes, necessitating the removal of one electrode.

Towards the end of the run one of the cast-iron, water-cooled stuffing boxes developed a bad crack, which allowed large quantities of water to escape into the furnace. This would not have occurred had sufficient time been allowed for the thorough testing of all the castings, and cannot happen in the future, since the design of these water-cooled stuffing boxes has been changed. But even while running with only two electrodes the output again began to rise when the heat lost by the water escaping into the furnace was partially restored to the walls of the furnace and to the wet charge in the shaft.

The time limit set by the director of the company for the delivery of power to the furnace was January 1, 1909. It was necessary, therefore, that the latest charge in the furnace should be all melted down and tapped out prior to that date. This was accordingly anticipated, and the official trial run was discontinued at 6 a.m., December 29, 1908.

In the following table is given the number of tons of pig-iron produced per electrical horse-power year, in casts Nos. 2 to 10, inclusive :—

Cast No.	Tons of pig iron per E.H.P. year.
2..	0.744
3..	1.870
4..	2.180
5..	2.360
6..	2.440
7..	1.120[1]
8..	3.160
9..	1.950
10..	1.030

[1] Electrode holder began to leak badly.

From the foregoing table it will be seen that the output before the leakage of water into the furnace became serious was 2.44 metric tons per electrical horse-power year. This figure, considering the disadvantages * under which the trial run was made, may be deemed very satisfactory.

Owing to the short duration of the trial it was impossible to determine the consumption of electrodes per ton of pig-iron produced. According to former tests, however, this may be placed at about 5 kgs. per metric ton (2204lb.) of pig-iron produced.

Technical Objective of Trial Run.

The trial run was intended to elucidate the following points :—

(1) Whether undisturbed and uniform working without troublesome regulation of the electrodes could be obtained.

(2) Whether great variations in the consumption of energy would occur.

(3) Whether the free spaces within the melting chamber would be maintained with a shaft considerably higher than in the furnaces of earlier design and construction.

(4) Whether the contraction of the shaft would prevent the charge from sinking uniformly, or cause hanging.

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* Water leaked into the furnace in small quantities from the beginning of the trial, but was not so noticeable until after the seventh cast.

(5) The durability of the arched roof, and the possibility of cooling it by means of the circulating gas.

Deductions from Observations.

The following is a summarised statement of practical deductions drawn from observations made during the trial run, having regard to the objective points specified above:—

(a) It was observed that the furnace operated uniformly and without trouble of any kind, and that the electrodes required absolutely no regulation, in one case for five consecutive days. In any case, the only regulation required is that corresponding to the consumption of the electrodes, and is necessary only once a day, and sometimes not for much longer periods. On account of this, expensive regulation can be dispensed with.

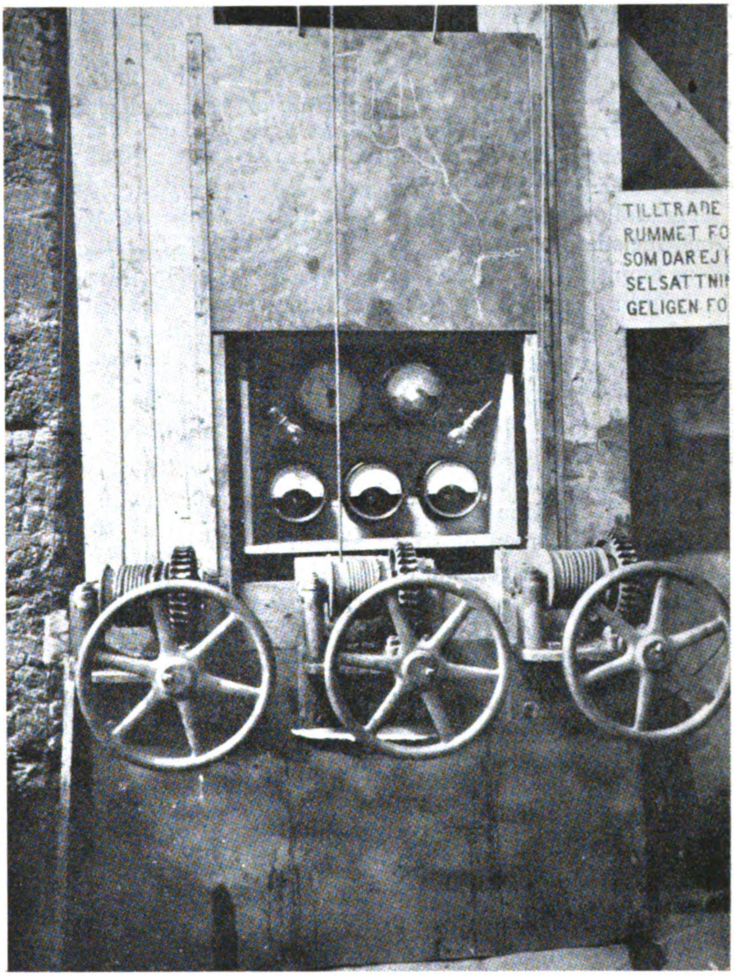

FIG. 7. WHEELS FOR ELECTRODE CONTROL AND INSTRUMENTS.

(b) During the short trial, even though the furnace did not approach its normal working condition until towards the end, it was observed that the consumption of energy was remarkably uniform. This can readily be seen from an inspection of the readings of the different instruments, a full tabulated record of the tests being reproduced in Mr. Haanel's original report.

(c) Free spaces were maintained between the linings of the roof and walls, and between the electrodes and the charge at the openings where the electrodes enter the melting chamber.

(d) It was found that the charge did not jam in the lower contracted neck of the shaft, as had been feared, but moved with regularity into the melting chamber.

(e) Although the gases generated by the reduction of the ore were not circulated through the cooling tuyères until near the end of the trial run it was demonstrated that the lining of the roof of the melting chamber was effectively cooled by this means.

Comparison of the Cost of Production of Pig-Iron in the Charcoal Blast Furnace with that Produced in the Electric Shaft Furnace.

The following particulars by Professor Von Odelstierna, of Stockholm, are added as a supplement to Mr. Haanel's report. It should be noted that the figures given are based on conditions ruling in Sweden.

If we take as a basis for our comparative study an ordinary charcoal blast furnace and the electric shaft furnace erected at Domnarfvet, and suppose the iron ore used in these furnaces to contain 60 per cent. metallic iron and the charcoal 83 per cent. carbon, then it should be possible to make a reliable comparison. It should be pointed out, however, that in this comparison no account is taken of the fact that the gases produced in the electric shaft furnace contain a higher percentage of CO—probably 60 per cent. more—than the ordinary blast furnace gases.

In regard to the labour charges and general expenses the supposition is made that these charges are the same for both the electric shaft furnace and the charcoal blast furnace, if the contrasted furnaces are of such capacity as to produce the same quantity of pig-iron per year. A charcoal blast furnace of medium capacity produces in Sweden about 8,000 to 10,000 short tons of pig-iron per annum—a quantity which can also be produced in a properly-constructed electric shaft furnace of the type of that of the Aktiebolaget Electrometall.

COST OF PIG-IRON PER SHORT TON IN DOLLARS.

CHARCOAL BLAST FURNACE.

Charcoal, 0.95 ton at $8 per ton..	$ 7 60
Electrical energy	0 00
Labour	1 00
Electrodes	0 00
Repairs and general expenses ..	1 50
	$10 10

ELECTRIC SHAFT FURNACE.

0.27 ton	$ 2 16
0.3 E.H.P. year at $12	3 60
Labour	1 00
10lb. at 3c. per lb.	0 30
Repairs and general expenses ..	1 50
	$ 8 56

In this calculation the prices of ore and limestone and the royalty are not given, as the former vary with the locality and the character of the ore, and the latter has not yet been determined.

From this calculation it is apparent that in Sweden, under the above-mentioned circumstances, a saving of $1.55 should be effected in the production of pig-iron by the electro-thermic process.

A 110,000-VOLT TRANSMISSION.

THE electrical system of the Grand Rapids-Muskegon Power Company of America is of extreme interest to all power engineers, as employing the highest voltage yet brought into practical use for transmission service. In addition to employing a higher pressure than previously attempted, the plant is unique in its simplicity, as will be gathered from the following details, which appeared in a recent number of *The Electrical World*. The only automatic device in the whole system is the speed regulator for the water turbines. In the high-tension lines there are no fuses, switches, or cut-outs and no lightning arresters. Even in the low-tension side of the transformers at the generating station no use is made of regulating devices or automatic switches of any kind. As a matter of fact, the leads from the 6600-volt generators are connected directly to the primary coils of the transformers, and the secondary coils are joined directly to the 110,000-volt transmission lines without the insertion of any device whatsoever. In the generator leads there are oil switches operated by solenoids controlled by inverse-time element, bellows-type, overload relays, but the switches have been plugged shut so that they are no longer in circuit. However, the system is protected from overload by circuit-breakers in the distributing circuits, while the fact that the turbines are incapable of operating the generators at a dangerous overload furnishes additional protection.

Experiments have shown that when the voltage on the transmission line is increased by, say, 10 per cent. the line loss due to "corona" discharges increases by almost 100 per cent. This condition shows that the line is operated at a voltage only slightly below the maximum permissible value for the present physical arrangement of the circuits. Due to this fact, any increase in the pressure induced by lightning produces an excess of corona loss, and tends to minimise the disturbance from lightning, while the high factor of safety used in the line insulators provides protection to the line. This conclusion seems justified by the operation of the 110,000-volt line continuously under lightning conditions which caused damage to an adjacent 70,000-volt line constructed along the same right-of-way according to standard practice, and provided with the usual lightning protective devices. However, for the protection of the apparatus at the terminals of the 110,000-volt lines use will be made during the coming season of lightning arresters of the electrolytic type.

The energy for the 110,000-volt system is obtained from a hydro-electric installation at Croton, on the Muskegon River, from which place it is transmitted forty miles to Grand Rapids. A dam across the river at Croton affords an effective head of 40ft. by joining a lake twelve miles in length along the bed of the Muskegon. The dam, which is of concrete, provides one of the walls for the turbine house and generator-room. It is equipped with motor-operated discharge gates and log spillways, but no extra precautions have been taken for the removal of floating ice, because the still water of the lake allows the ice to form and then to melt without floating down stream.

The generating equipment consists of two 3000kw. Westinghouse, three-phase, 6600-volt, 30-period alternators, each of which is driven by eight horizontal-shaft Leffel turbines to which it is direct-connected.

The reason for using so large a number of turbines for each generator resides in the fact that for the head available the arrangement selected afforded the most economical equipment for the power developed. The speed of each generator is controlled by two Lombard governors, each of which regulates the water admitted to two pairs of turbines. The speed at which the governors tend to cause the generator to operate is set by means of a miniature direct-current motor receiving power from the exciter circuits and remotely controlled by push buttons on the switchboard. A synchroscope is used in paralleling the two generators for connection through 6600-volt bus-bars.

Each alternator is provided with a 40kw. exciter mounted on an end of its shaft extended beyond the main ring-oiler bearing. The usual array of exciter instruments and controlling devices is conspicuous by its absence. The exciter terminals are joined directly to the terminals of the field coils of the alternator, the only method of varying the e.m.f. of the alternator being by means of the rheostat in the field circuit of the exciter generator. The exciter is a compound-wound machine, but the series coils are not used. The alternator is provided with a field-circuit rheostat, but this has been abandoned. Moreover, the 6600-volt oil switches in the main alternator leads are no longer used, as noted above. The switchboard for each alternator contains a single ammeter and wattmeter, two push-button devices for setting the speed of the machine and an exciter field-circuit rheostat; the handle for the 6600-volt switches, which are located immediately behind the board, an overload relay and an alternator field-circuit rheostat are also represented on the board, but are not utilised.

The only devices in the main alternator leads are air-break disconnecting switches and series transformers. In case it becomes necessary for the attendant to open the circuit under load the oil switches, which normally are fastened in the closed position, can be released and operated by hand or by the relay.

The 6600-volt leads are joined directly in delta to the primary circuits of three oil-insulated, water-cooled transformers, the secondary circuits of which are connected in delta to the 110,000-volt transmission lines. The only prominent features of the transformers are the secondary bushings, which have been made extra long for the high voltage. The lines leave the building by way of porcelain disc bushings mounted in wooden windows; each line is anchored against the opposite side of the building by five disc-type strain insulators, each of which is rated for 25,000 volts and the five for 125,000 volts.

The transmission line contains three cables suspended by disc insulators from steel towers, spaced ten per mile. Each cable consists of six strands of No. 10 copper wire with hemp core. Joints in the cable are made by means of figure 8 copper tubing, which is given a total of three complete turns per joint. There are five 25,000-volt insulating discs at each point of suspension. The efficiency of the arrangement of the line is shown by the fact that the only mechanical defect was developed during an unusually severe sleet storm, when one of the cables gave way under the excess load, while the only electrical breakdown occurred to two of the five discs at one tower, which caused no interruption, because the remaining three supported the line and provided adequate insulation.

At the main substation in Grand Rapids there are three 3750kw., oil-insulated, water-cooled transformers, duplicates of those at the generating station. No switches are used in the primary leads, which are joined directly to the 110,000-volt transmission cables by an arrangement similar to that used at the generating station. The substation is provided with the usual equipment of recording devices, oil switches, etc., for a 6600-volt distributing system.

Air-insulated bus-bars allow the 110,000-volt transmission system to be paralleled on the 6600-volt secondary side with a 70,000-volt system which transmits energy sixty miles from Rogers Dam, twenty miles upstream on the Muskegon above Croton. For the latter system the substation contains three 1250kw., 70,000-volt to 6600-volt, oil-insulated, water-cooled transformers. The 70,000-volt transmission wires are carried on pin insulators arranged on wooden poles. For forty miles—that is, to Croton—the 70,000-volt line runs adjacent to the 110,000-volt transmission system. A compartment in the station at Croton is employed for the disconnecting switches of the 70,000-volt circuits, but these circuits are in nowise inter-connected with the 110,000-volt system except at the Grand Rapids substation through the transformer secondaries, as indicated above.

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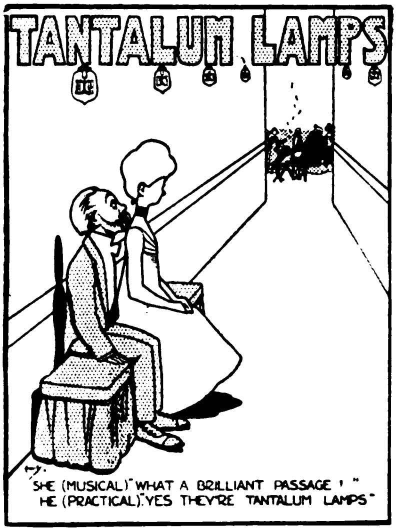
TANTALUM LAMPS
SHE (MUSICAL) "WHAT A BRILLIANT PASSAGE!"
HE (PRACTICAL) "YES THEY'RE TANTALUM LAMPS"

The above is a reproduction of the new show-card issued by Messrs. Siemens for furthering the sale of Tantalum lamps. The original, in attractive colours, represents Hassall at his best, and will compel universal attention in the electrical contractors' offices and showrooms throughout the country to the lamp which is already a well-established favourite. The gentleman illustrated is certainly typical of the practical man who can only associate brilliancy with the modern electric lamp. The makers of the Tantalum lamp report an ever-increasing sale. This further happy venture in publicity will undoubtedly be a strong factor in still further popularising a lamp which has proved to be as pleasing in its effects as in its economy.

THE ELECTRIC PROPULSION OF SHIPS.*

As previously stated, the commercial development of ship propulsion by electric power had perforce to await the production and perfection of means of generating electricity cheaply. The great advances made recently in the design and construction of efficient, cheap, light-weight and high-speed prime-movers, such as are the modern internal combustion engines, together with the increased knowledge of the principles and construction of heavy electrical machinery of large output capacity, have made the question of electrically propelling ships of large size appear within sight. Moreover, reliable figures and data are now procurable, with the consequence that marine electrical propulsion can now be discussed with real interest and a view to immediate practical usage. When dealing with the enormous powers that are used in this vast sphere it is essential that the progressive electrical power engineer shall co-operate with the equally progressive marine engineer. This combination of practical experience once applied will, in the author's opinion, secure such great fuel economies, and therefore low coal cost per ton of displacement per mile at any given vessel speed and form, that owing to the ever-increasing competition in shipping circles no firm of owners will be able to subsist without it. Nor is it a matter of years before the general adoption of electrically-driven propellers will be forced on shipbuilders by the demands of the shipowners in their endeavours to meet the ever-increasing competition in maritime commerce. This opinion as to the pending introduction of electric power for ship propulsion is based on facts realised by actual investigation, and making comparisons in detail of electric propulsion as against the existing driving plant of various well-known vessels, taking cost, weight of plant, and power transmission efficiency from engine to propeller into account. It should be borne in mind that the propeller is *the* controlling factor in the matter of efficient ship propulsion, and, although many ways of producing or generating power with great efficiency are possible, the most important fact is that great losses may take place *at the propeller.* The main object of the propeller is to produce *the maximum thrust per horse-power delivered to it.* As was pointed out in the article which appeared in the April number of THE ELECTRICAL MAGAZINE AND ENGINEERING MONTHLY, in order that the propeller may produce the utmost amount of thrust per horse-power it must be run at a suitable slow speed in revolutions, while the latest prime-movers, such as steam turbines and internal combustion engines, to be "efficient" must be run at comparatively "high" revolution speeds. Thus a link for speed reduction must be introduced between the prime-mover and the propeller, and although many methods have been suggested to meet this requirement none offers the advantages that a properly-designed electrical transmission affords, and electricity will beyond doubt be employed for the purpose of forming this most necessary link.

Marine engineers are a most intelligent class of men, and owing to their long and practical experience with pure mechanical engineering reasonable allowance must be made for their want of knowledge in heavy electrical power engineering; it is therefore more or less to be expected that they may display some hesitation when approached on this subject as to the introduction of electricity between the prime-mover and the propeller. At first sight it certainly may appear a step in the wrong direction, but if they can be got to go into the matter thoroughly it will be evident to them, as well as to many other engineers, what is in store for the progressive owner who has an electrically-driven vessel when compared with existing working conditions, &c.

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* A continuation of the very complete illustrated description dealing with the history and development of this important subject which appeared in THE ELECTRICAL MAGAZINE AND ENGINEERING MONTHLY of April and May of this year.

In a case in hand for the application of the internal combustion engine in combination with electric power for ship propulsion it has been decided that the propeller shall run at a speed of 100 revs. per min., and utilise 500b.h.p. for producing thrust for propulsion on the thrust block. In order to supply the necessary mechanical power an induction motor will be used capable of giving the required output, and working with an efficiency of 91 per cent., therefore requiring, say, 410kw., delivered at its terminals, when working at full vessel speed. The distance between the generator and the motor being 30ft., the transmission losses, as regards line voltage, may be left out of the calculation, as they will be a very small amount and more than covered by allowing an efficiency of only 91 per cent. for the motor, which is more likely to be about 93 per cent. in practice. It is proposed to install in this instance two high-speed suction-gas engines, each of the same horse-power and running at 413r.p.m., each of which will be capable of yielding at that speed 300b.h.p. The "Paragon" electric system is to be adopted for generating the current with variable periodicity similar to that described on page 192 of the April issue of this magazine, but with a slight alteration as regards the method of arranging the working of the magnetic flux. In the illustration given on the above page in the earlier article referred to is shown a prime-mover having a speed of 1000r.p.m., with a four-pole synchronous generator and a 12-pole transformer-generator, the combination giving, say, three speeds efficiently on a 60-pole polyphase squirrel-cage induction motor, with a top speed of 266.6r.p.m. In the lay-out for this suction-gas engined ship the working is different, inasmuch as there are two prime-movers; one engine will drive a 12-pole synchronous three-phase generator, while the other will drive a 6-pole transformer-generator. The working will be as follows, assuming that the engines are started up and they are left governed at the above speed of 413r.p.m. (see Fig. 1):

Engine A drives 12-pole synchronous generator revolving magnet B excited by continuous current exciter C; three-phase current, with a periodicity of 4956 alternations per minute, can now be drawn off the stator armature D. This current can either be coupled to the switch-contacts G or to the slip-rings F through the change-over switch S; if the switch S is placed on contacts sI then the direction of the current is in the way shown at Q. The magnetic flux in the air-gap of the transformer-generator revolves in the direction marked at U. This transformer-generator having only six poles and being driven at the same speed by the second engine I as the revolving field B by engine A means that for every mechanical turn of the primary of the generator-transformer H the magnetic flux revolves twice; the consequence is that three-phase alternating current can be drawn off the stator secondary J at a periodicity of 2478 alternations per minute, at about 66 volts between phases. The motor being wound for 72 poles and 200 volts between phases, and the switch L being placed on contacts 12 and switch M being placed on contacts mI, the squirrel-cage rotor O turns in the ahead direction, and with, say, 3 per cent. slip, runs at about 33r.p.m., that is, say, the first speed. The next speed can now be obtained in the following manner: If for a very long period, such as in fogs, &c., the engine I and its transformer-generator may be closed down and the current taken from the armature D by turning switch S off and closing switch L on the L1 side (it is here necessary to bring the switch M on to the m2 side because it will be observed that the direction of the current is reversed); the rotor O will then accelerate in, say, the ahead direction with, say, 3 per cent. slip, at about 66r.p.m., with the 4956 period current from armature D direct. If prime-mover I is again started up and the current disconnected from the motor by bringing the switch L to the L2 contacts, then if switch S is brought to the contacts s2, the direction of the current going into the primary of the transformer-generator H marked at R is reversed, and consequently the magnetic flux revolves in the same direction as that of the mechanically-driven H marked at V. The result is that current can now be drawn off stator secondary J with a periodicity of 7434 alternations per minute, which current passing through switches L and M, the rotor O then runs at, say, with 3 per cent. slip, 100r.p.m., and that is the top propeller revolution and full vessel speed. The direction of the prime-movers is marked at T, which is always the same whether the vessel be going ahead or astern; as is well known, it is only necessary to bring the switch M to the opposite contacts for reverse at either of the above speeds. The changing of the connection in the above-stated cases can be carried out under no-voltage condition by simply bridging the field of the exciter with a contact switch marked at E, the operation of which may be made automatic with oil switch contacts so that it would be impossible to move any main contact under live conditions, as the exciter immediately loses its field, the excitation falls, and the whole system comes to a no-voltage condition. On opening the circuits the rotor is still being turned in, say, the ahead direction by the speed of the vessel drawing the propeller through the water, so that the acceleration of the motor after changing the connections, which is only a matter of seconds, is only from the last speed, whichever that may be, in any instance. It will be observed that the slip-rings F only take the current from the armature D and that the main current equal to the top speed of the vessel is drawn from the stationary winding of transformer-generator J, and that the aggregate energy of both engines is represented in electrical energy (minus ordinary losses) at the terminals of J and can be delivered to the stator of motor N. In this case the over-all power transmission efficiency is guaranteed to be not less than 84 per cent. from the b.h.p. of both prime-mover shafts at 413r.p.m. to b.h.p. delivered to the propeller shaft at 100r.p.m.

The fact that the induction motors may be run at high efficiency in either direction ahead or astern means that the gas engines may be constructed on the simplest of lines, with offset cylinders, and therefore getting the utmost of thermal and mechanical efficiency out of same, and this method avoids the complication that would otherwise exist with any attempt at trying to make a satisfactory reversing gas engine for main marine propulsion; at the same time this allows of the absence of mediums such as compressed air for reversing the propeller. It is also to be noticed that the engines in this case run at more than four times the speed of the propeller, therefore their working parts are much lighter and smaller than would otherwise be the case if it should be suggested to couple a suitable gas engine direct to the propeller at the speed, namely, 100r.p.m., in which case the weight of the engine, owing to its having to deal with the heavy torque, would be much heavier than the combined high-speed engine, generator, and electric motor, quite apart from the larger amount of valuable space that same would occupy in the vessel. The fact that the whole control of the propeller will

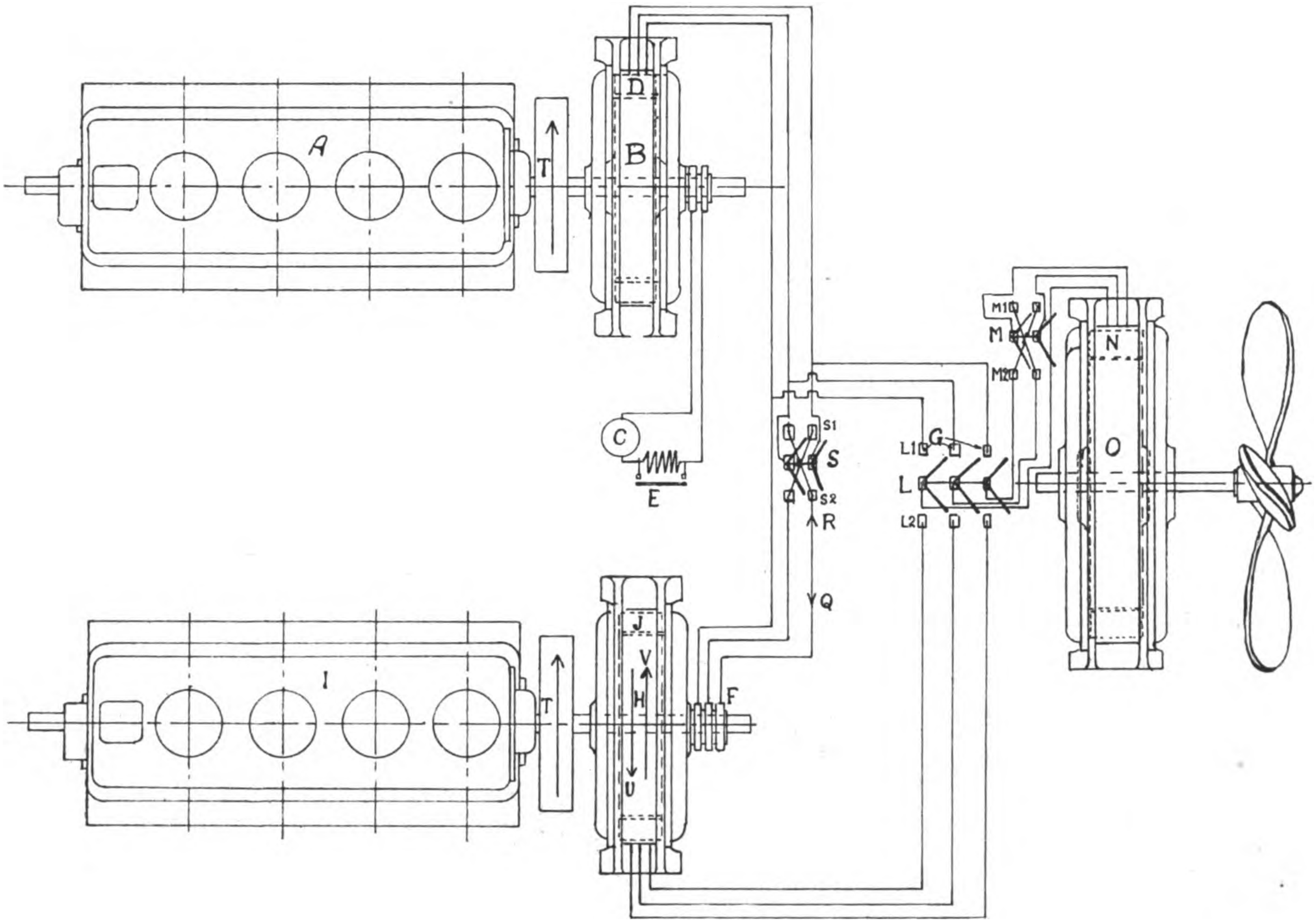


FIG. 1.
The lay-out of the "PARAGON" System of Electrical Driving for propulsion by means of the variable periodicity Alternators, Squirrel Cage Induction Motors and Propellers running at slow speed, with the Engines and Generators running at high speed. This arrangement is especially suitable for slow-speed Cargo Vessels, in which the direct-coupled International Combustion Engine is not suitable owing to its high speed in revolutions.

in this instance be carried out from the bridge is almost sufficient by itself to recommend the adoption of electrical power transmission, quite apart from the fact that by means of the "Paragon" system of generating the current at variable periodicity and voltage the speed of the propeller may be varied with efficiency without the necessity of varying the speed of the prime-mover. If the reader will turn to the diagram showing the fuel consumption per h.p. developed, on page 326 of this magazine of last May, it will be evident that, in order to obtain the most work from a given amount of fuel burnt in an internal combustion engine, it is essential to run the engine at constant speed, which may be done in the method described above.

At the present period it is a most difficult thing to make internal combustion engines of very large power owing to the limitation of the dispersal of heat in a given time from the large cylinders unless such engines are fitted with some special cooling medium, such as water-cooled pistons, etc. The consequence is that to make up an engine of very large power it is necessary to have a multiplicity of cylinders, and it becomes very necessary to have some accurate method of timing the ignition in order that the highest efficiency shall be got out of a certain amount and quality of fuel. In the case of motor-cars it has been found that on large racing cars it pays to stop and tune up (as it is termed) and synchronise the ignition owing to the wear on the tappits, which even after a few hundred miles become uneven to such an extent that the efficient timing is upset and the utmost of work from a given portion of fuel is not obtained. It may be left to the imagination of the reader what such accurate adjustment would mean in a reversible gas engine for use at sea. The necessary setting of valves that would be required under such circumstances and the loss that would take place would be more costly than would be represented by the electric conversion of the prime-mover power at high revolution speed to slow propeller revolution speed. The raising of the engine speed, as in the case of electrical power transmission, means that a great reduction can be made in the weight of the internal combustion engine for this purpose, and this, together with the higher efficiency in fuel of non-reversible engines more than compensates for the extra weight and cost of the electrical plant necessary. Moreover, it is not possible to make internal combustion engines to run at the very low speeds that are sometimes necessary in fogs, etc., at sea.

A scheme that the author recently got out for a large firm in the North of England is interesting because of the fact that the gas engines proposed to be used for main marine propulsion were to be coupled direct to the propellers at top vessel speed and the intermediate speeds and the reverse were to be obtained by means of squirrel-cage induction motors. Fig. 2 shows the arrangement put forward—suction-gas engines were proposed—it was for a twin-screw vessel. Two engines, each of 375b.h.p., at 200r.p.m., are shown at A; one gas engine was to drive the "Paragon" variable periodicity alternator B, which was to be excited from a small exciter at the other end of the engine C; the shaft of the engine continued through the generator and ended up by driving the live half of a magnetic clutch D, the before-mentioned items running at constant speed at all times. Coupled to the propeller shaft is the squirrel-cage motor E running in bearings FF, on the outside of which and in line with the engine is the armature side of the magnetic clutch D.

The working is as follows: Assume that the engine is started up and runs governed at 200r.p.m. By putting the exciting current on to the revolving field of the variable periodicity "Paragon" generator B and by suitably coupling up the motor

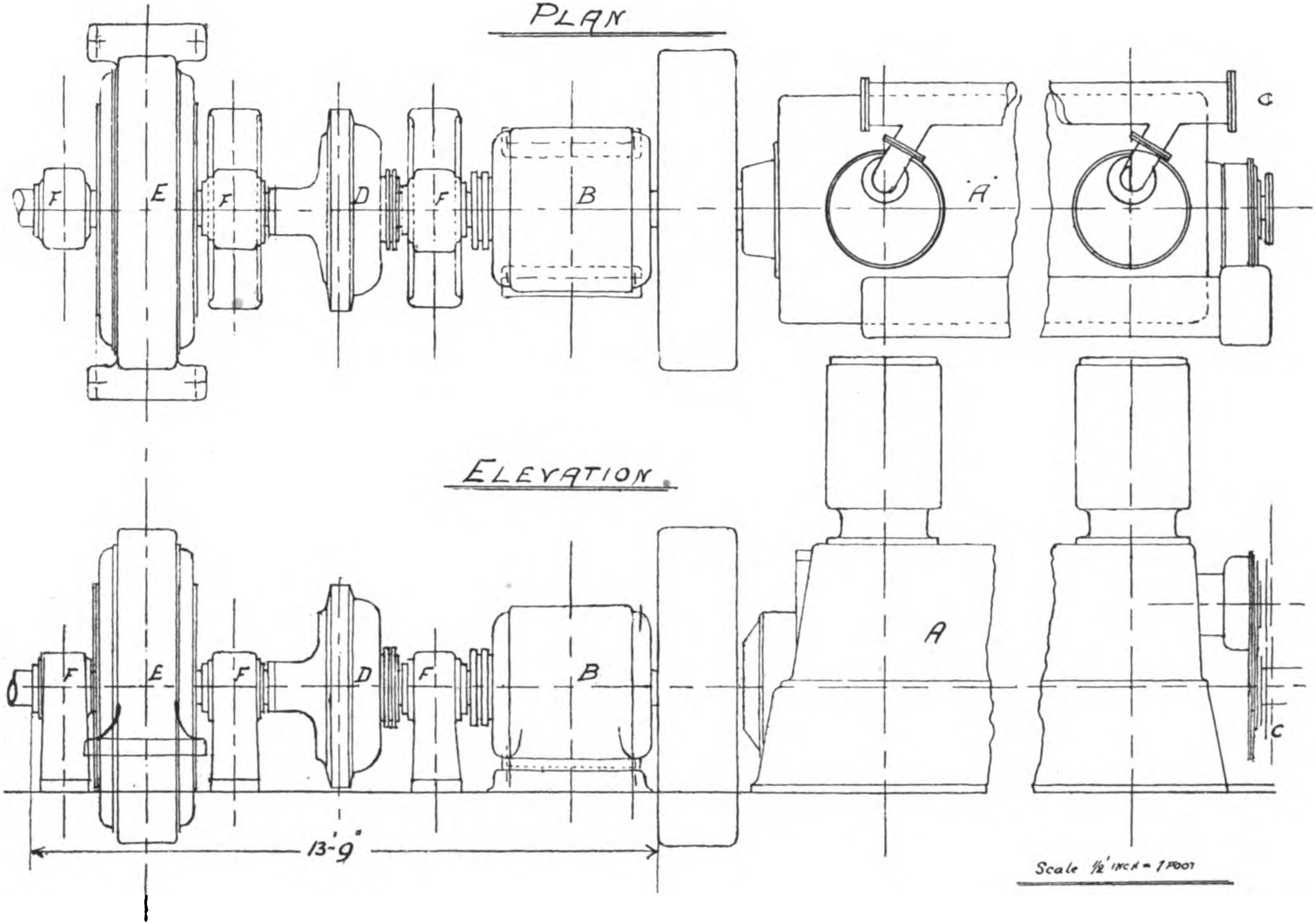


FIG. 2.
The lay-out of the "PARAGON" System when arranged that the Engine shall drive the Propeller direct at Top Vessel Speed, the intermediate speeds being got by means of the Variable Periodicity Generators and Squirrel Cage Motor.

with same *three different speeds below 200r.p.m.* may be given in either direction, i.e., ahead or astern, to the propellers, say 50, 100, and 150r.p.m., while at the above propeller speeds the magnetic clutch is not excited, so that there is a difference in speed between the engine and propeller shafts. Now, if the exciter is taken off the alternator and connected with the live or slip-ring side of clutch D the same immediately engages and the propeller shaft is raised to the engine speed of 200r.p.m. This represents the top propeller and vessel speed, and at this speed the revolving magnet of the alternator, the clutch, and the rotor of the motor form further flywheel effect for the engine, the generator and the motor running idle, the whole work of the engine (except the small amount that is represented by the exciting current) is thus delivered to the propeller shaft.

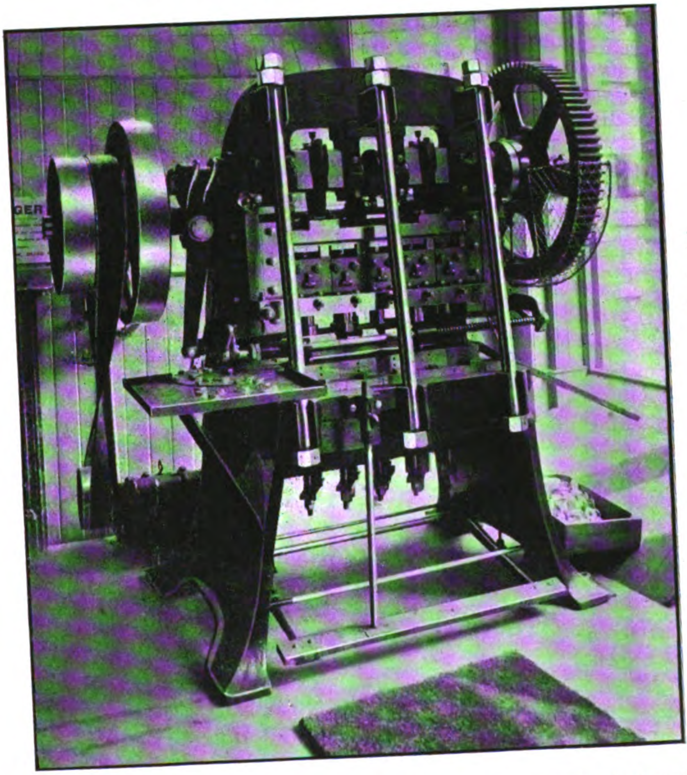
At first this may appear to be the most efficient way of dealing with the matter of propelling the vessel, as the power of the engine is right on the propeller shaft, but this is not the case. It is certainly very interesting but not the most efficient way of producing the most thrust on the thrust-block with the power available with the above type of engine, and this is certainly not the case in the matter of a slow speed vessel such as a tramp or cargo boat, where the vessel speed is only possibly, say, 9 knots. In vessels of this speed the most thrust is produced (with the amount of draught available) when running the propeller shaft at, say, 70 to 80r.p.m., and this low speed necessitates the employment of propellers with blades of large surface, and therefore of large diameter. These propellers, although taking less power to produce a certain amount of thrust, require, at the lower revolution speed, more torque than that produced by the above engines running at 200r.p.m. ; further, it can be proved that more over-all efficiency can be got if the engine speed be raised to 413r.p.m. (as in the case of Fig. 1) instead of 200r.p.m. (as in Fig. 2), thus reducing the weight of the engines per h.p. If electrical power transmission be used it will provide not only the connection between the engine and the propeller, but also gives an efficient means of reducing the speed to, say, 80 or 100r.p.m. on the propeller, the consequent increase of thrust resulting in an increased propulsive-efficiency per horsepower delivered to this slow speed propeller as compared with that produced with the higher-speed direct-coupled one. Further, the fact that the control of the above methods of propeller-driving may be operated from either the bridge or the engine-room as may be desired is a very important factor in favour of electrical power in conjunction with the internal combustion engines for this duty. As regards reliability of working there is no question about the robust character of the polyphase-current machinery involved in this method of power transmission, as, having no commutation to deal with and the very short distance that the power has to be transmitted, the voltage is very low—points which make for high efficiency in the design of the machines and perfect reliability.

A further advantage of this method of propeller-driving is the fact that in very large vessels, where the power will run into, say, 20,000 shaft horse-power, it is obvious that several internal combustion engines may drive variable periodicity alternators and concentrate their aggregate power into, say, one induction motor ; thus four propellers could be driven by four 5000b.h.p. motors, one on each propeller shaft. These motors could be run at, say, 100r.p.m., and the necessary electrical energy could be supplied by eight two-cycle 2850b.h.p. engines running at a constant speed of 250r.p.m. and arranged on similar lines as per Fig. 1. By this arrangement four efficient speeds could be given to the motors in either the ahead or astern direction, and at cruising speeds, say, four of the engines could be closed down and great economy in fuel at these slow vessel speeds maintained. Owing to the light total weight per shaft horse-power developed of such an installation as compared with that of a similar steam power undertaking, the draught of the vessel would be less, and for the same shaft horse-power provided the vessel speed would be higher, so that not only would the fuel economy be greater per shaft h.p. but the horse-power hours per voyage with given cargo or passengers would be less.

There is no question that is so vital and calling for the serious attention of members of the electrical engineering trades than their co-operation with progressive internal combustion engine makers, shipbuilders, naval architects, and owners, with a view to a thorough investigation, than is the subject of this article. A careful study of the conditions will reveal the vast potentialities of the electrical method of driving ships. In this and the preceding articles the author has followed the theoretical and practical considerations bearing on the subject; inquirers going into details in the directions indicated will prove for themselves what tremendous commercial advantages are in store for the progressive ship-owner who will give this system of propeller-driving a trial.

WILLIAM P. DURTNALL,
M.I.Mar.E., M.I.Auto.E.

COMBINATION FEED PRESS.



The above illustrates the No. 102-S combination feed press, by Messrs. E. W. Bliss & Co. These presses are made in three sizes with five, six, or more slides, and are designed to produce with great speed and economy such articles as require a series of operations, such as electrical brass fittings, &c.

THE WORLD'S PROGRESS IN ELECTRICAL AND GENERAL ENGINEERING.

Electric Operation of Pit-Heap Haulage.

ONE of the more considerable sources of expenditure in some coal mines is the removal of the waste from the dumping ground and its disposal at a suitable spot further on. Hitherto this has been done by steam, a common arrangement being for one digger to work with two locomotives and the necessary number of tip-wagons. In some cases the gradients are very steep and the trains so heavy that, owing to the small gauge loco not being sufficiently powerful, it is necessary to use two engines. It may therefore be necessary to employ eight men on the trains serving one digger—four drivers and four firemen. By using electric locomotives sufficient power can be concentrated in one engine, only one driver is necessary, and he need not be a skilled workman. Thus the saving effected in the service of each digger is represented by the wages of two drivers and four stokers.

At first glance it would seem difficult to effect an important saving in fuel, which is to be had in abundance on the spot; but, as a matter of fact, in mines producing inferior qualities of coal, lignite, &c., the saving may be quite important. The reason is that lignite and other similar fuels require a large grate area for effective combustion; they lack this on the locomotive, while in the power station the grate area can be increased and made suitable to the type of fuel. Although the above considerations have been known for a long time and have been generally recognised by mine managers, they have hesitated to employ electric traction for another very practical reason, namely, the difficulty of providing an overhead system capable of carrying the very heavy currents required by the locomotives, and at the same time capable of following the frequent shifting of the tracks, which have often to be jacked over several times daily as the heap progresses. This difficulty has been overcome by the Siemens Schuckert Company, who have supplied the necessary plant for two important German lignite mines. A description of the means employed appears in the "Elektrische Kraftbetriebe und Bahnen."

The masts carrying the trolley wire consist of a stiff channel iron bent to a right angle, the horizontal portion being bolted to one of the sleepers of the road. The upright portion, which is less than half the height of the complete pole, has clamped to it a piece of stout iron barrel which is bent over at the top and carries the insulator. The ear is not rigidly attached to the insulator, but is carried by a rod which can slide longitudinally in an eye fixed to the insulator. This arrangement, which has worked extremely well, allows of the necessary movement when the roads are being moved over.

The section of the trolley wire used is 80 sq. mm. ($\frac{1}{8}$ sq. in.). Considerable difficulties had to be overcome in the design of the collectors, which, owing to the roughness of the work, could only be of the bow type. Firstly, the maximum current to be taken from the line was very heavy, and, secondly, the height of the trolley wire varied from a minimum of 2.55m. (8ft. 4in.), governed by the portal of the digger, to a maximum of 5m. (16ft. 5in.) over a public road.

The maximum current being of the order of 800amp., each locomotive is fitted with two separate collectors, each collector having a double contact bow, one fore and one aft of the main carrier. The main carrier is hinged on the roof of the locomotive, and is pressed upwards by a spring. The double bow is pivoted on the end of the main carrier and is also spring controlled; but it is arranged in such a way that up to a wire-height of 4m. (13ft.) both bows make contact and consequently remain in the horizontal position. The pivot point of the bows is nearer to the one bow than the other, and the spring tends to force up the long end. As soon, therefore, as the wire rises above the four metre limit, the long end bow is forced up and maintains contact up to the maximum height of five metres. It will be noted that at this point only one bow on each collector makes contact; but this does not matter, because the high points of the wire are only at public road crossings, *i.e.*, when the line is level and therefore only a moderate current is required.

The locomotives are also of special design and call for short notice. The gauge is 35½in., and very little overhang can be permitted, also, owing to the restricted headroom, the driver's cab has to be dropped in between the two bogies. High adhesive power is necessary owing to heavy gradients and a loosely laid and very rough road. The necessity of dropping the cab has the effect of making the engines long and spreading the weight over a greater surface. This, of course, is an advantage. The locomotives vary from 28 tons to 44 tons weight in the different mines. The bogies are very freely articulated, so that derailments are of rare occurrence. The engines are about 32ft. long and have a small platform at each end for the shunter. The horse-powers of the locomotives in the two mines under consideration are 240h.p. and 325h.p. respectively, with speeds of 10 to 15 miles per hour. The heavier locomotives have air brakes as well as hand brakes, and are fitted with airblast sandboxes. The compressed air tanks are automatically kept up to pressure by a small motor-driven compressor. The bucket-digger is likewise driven electrically, and takes power from the same trolley wire, which, as before mentioned, runs through the portal of the digger carriage. The bow collector of the locomotive slides over the collecting piece of the digger without breaking contact.

The experience gained in these installations demonstrates the superior economy and reliability of electric traction over steam traction in this special application, and it is probable that further conversions will shortly be put in hand.

◆

The Quartz Lamp. THE mercury lamp, invented by Arons and greatly improved by Cooper Hewitt, is well known. Its distinguishing characteristic is its unpleasant blue-green light, and the peculiar shape of the lamp itself, which, for 110 volts, is over a yard long. The mercury vapour therein is in a very ethereal condition. Such a lamp will burn about 1000 hours, and takes about 0.6 watt per Hefner candle-power. Dr. Küch has shown that with increased current this lamp shows at first a decreased efficiency, but with still a further increase of current there is a second increase in efficiency, so that it is possible by taking advantage of this fact to produce a more economical lamp. But here comes in the difficulty that at the necessary temperature of about 140deg. F. the glass tube of the ordinary mercury lamp commences to soften. To get around this difficulty Küch made a lamp out of melted quartz, and increased the current still further. Naturally, the temperature of the mercury rose proportionately; and the lamp, instead of working under vacuum, had an internal pressure of one atmosphere. Considerable economy was effected, as the power necessary was reduced from 0.6 watt per Hefner candle-power to only 0.3; moreover, the lamp was smaller and of more convenient shape. A lamp for 220 volts is, for instance, only about 6in. long. The colour of the light could not be called beautiful, being much like that of the old mercury lamp; but not so unpleasant as that, as the quartz lamp emits a considerable quantity of red light also. This is very plainly shown by placing one of each kind behind a red transparent screen; the quartz lamp shines brightly, while the other is almost invisible. The quartz lamp is made for 2.5 to 4 amperes, and 110 to 220 volts. The power consumption when the lamp is provided with reflector, &c., is, for the lower hemisphere, about 0.3 watt per candle-power. The lamps can be used in almost any ordinary factory, and are readily interchangeable. They may be used for photographing, copying, for drying patent leather (to replace sunlight), for sterilising liquids (by reason of the bactericidal effect of the ultra-violet rays), under water (by reason of the lack of sensibility of the quartz to changes in temperature), and for medicinal purposes.

❧

The "Denny" Gold Medal.

IT will interest readers to learn that Mr. William P. Durtnall, M.I.Mar.E., M.I.Auto.E., has been awarded by the Council of the Institution of Marine Engineers the "Denny" gold medal for his paper on "Electrically-driven Steamships," read at the Congress meeting of the above Institute at the Franco-British Exhibition, July, 1908. Mr. Durtnall is the author of the very complete article on this phase of Electrical Marine Engineering that appeared in THE ELECTRICAL MAGAZINE AND ENGINEERING MONTHLY of last April and May, and which is further continued and brought up to date elsewhere in this number.

❧

Electric Rolling Mills.

THE use of electric power in rolling-mills is one of the most important subjects before electrical engineers in this country at the present time. Whilst there are a few installations already in operation there are quite a number of enquiries about for this class of work, and no little ingenuity and study is being given to the several phases of the subject by our leading manufacturers. As to power generation, where the main power is by steam engines the exhaust steam turbo-electric set holds the field; where new high-pressure steam plant is the order of the day opinions are divided as to the merits of high-pressure turbines, reciprocating condensing engines, and the combination of reciprocating sets with low-pressure turbine sets. For the present we may confine ourselves to the application of the electric motor to the driving of the rolling mills. That the importance of the subject to electrical men is fully realized in America is evident by the fact that three papers, all dealing with practice in this direction, were read before the American Institute of Electrical Engineers at their last summer convention. One, by Mr. E. W. Yearsley, dealt generally with the respective merits of the steam-engine drive and the electric motor, the author expressing himself as decidedly in favour of the latter.

The protection of the electrical driving plant is extremely important in the steel mill, where conditions are necessarily uncleanly, and electrical apparatus must work in the midst of dust, moisture, and gases. Large motors should be enclosed in solidly built compartments, ventilated by clean air if necessary, or they should be of the totally enclosed type.

The controlling apparatus for mill service is usually the weak part of the system; it is much less satisfactory than the motors. Mechanical strength and simplicity are the main points to be observed in designing this apparatus. Heavier and more mechanical switches and circuit-breakers, better protected and more durable rheostats, and more dependable automatic controlling devices, requiring less attention, are badly needed.

This is a problem more difficult of solution than the improvement of the motor, but no less necessary.

For large main-drive motors the advantage of continuous running at constant speed is so great that it would appear advisable to make the design of the mill suit the characteristics of the motor, and avoid the extra expense and complication of devices like the reversing drive. The tendency has been to build a machine and then to couple on a motor somewhere to drive it. This mistake, while not so frequent as formerly, is still made.

There seems to be no great difficulty in designing mills for continuous running motors. By combining such motors with a suitable fly-wheel, it should be possible to keep the line load sufficiently uniform. This combination has not received sufficient attention, possibly because of lack of knowledge of power and speed regulations of the rolling operation.

Tests of these characteristics will be comparatively easy on electric mills, so that data will rapidly become available for supplying the system with the proper inertia. In some installations the fly-wheel is so badly proportioned as to be detrimental to the operation of the motor. Initial speeds should be carefully selected, especially when the drive is direct, and if possible a considerable speed regulation should be provided, so that the speed may be increased with increase in proficiency of the operators.

The importance of low armature inertia for reversing motors is now well recognized, but designs could be improved by still further reductions in speed. In this connection the author of the paper is decidedly against the use of high-speed motors for any kind of mill service and believes the extra cost of slow-speed machines well warranted.

Electric motors subject to excessive vibration communicated from the gearing and other parts of the machine should be protected by a flexible coupling.

For mill apparatus, which must be handled directly, especially for direct-current apparatus, the author of the paper favours a maximum of 250 volts. The safety of employés requires that with higher voltages special guards be provided to isolate the apparatus.

Considered economically, Mr. Yearsley believes main electric motor drives to be superior to engine drives, even when power must be derived from a steam-engine-driven generator plant fed by coal-fired boilers. Steam losses due to condensation and leaky valves and rings are surprisingly large, but usually escape definite measurement. Then, in the usual rolling-mill engine, very little expansion is utilized, and it is not likely that attempts to refine such machines will be satisfactory. Where water power or waste gas is available there is no question of the greater economy of electric drive.

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Novel Steamship Design.

THE *Monitoria*, a new vessel of the Ericsson Shipping Company, is noteworthy as being the first to be built with the special hull construction devised by her designer, Mr. Arthur E. Haver. The objects of the innovation are to lessen skin friction and to increase stability, for which purpose the plates are provided with longitudinal corrugations, which give the section of the vessel a wave-like form. It is stated that this novel construction means a saving of 14 per cent. in horse power, or a gain of $\frac{3}{8}$ knot in speed. The cargo capacity is about 3 per cent. greater than that of the sister ships in the same fleet, while the speed is increased 5 per cent. for the same coal consumption. The strength of the ship as regards hogging and sagging strains is also considerably increased by the corrugations. The designer of the vessel is said to have spent five years in working out the experimental details of the new method of construction, and he is well satisfied with the results obtained. The *Monitoria* is a vessel 280ft. in length, with a moulded depth of 21ft., and a cargo capacity of 2500 tons. If other and larger vessels built on the same principle realise expectations, the inventor hopes that it will be adopted for ocean liners and for warships, since, in his opinion, it will conduce to speed, steadiness, and freedom from vibration.

❧

British Machinery Trade.

THE total value of machinery of all kinds imported into this country during 1908 amounted to £4,552,904. The imports from foreign countries were £4,438,331; from British possessions, £114,573. In the way of machine tools we imported 798 tons, value £99,014, from the United States, and 189 tons, value £16,494, from other foreign countries. The exports of British-made machine tools and their destination were as follows:—

	Tons.	£
To		
Germany	58	10,706
France	355	25,409
Italy	197	11,500
Japan (including Formosa)	2,477	110,620
Chile	240	12,340
Brazil	318	16,340
Argentine Republic	470	23,868
Other foreign countries	1,275	69,036
Total to foreign countries ..	5,390	279,819
British South Africa	69	4,543
British East Indies	1,465	69,491
Hong Kong	187	9,576
Australia	652	29,791
New Zealand	213	13,130
Other British possessions	207	10,031
Total to British possessions ..	2,793	136,562
Total	8,183	416,381

The re-exports from this country of machine tools made abroad (being machine tools shipped to the United Kingdom for transport to other countries) were as follows:—

	Tons.	£
To		
Sweden	15	984
Germany	9	4,263
Portugal	3	1,322
United States of America	19	5,380
Argentine Republic	8	1,381
Other foreign countries	22	2,500
Total to foreign countries ..	76	15,830
Natal	19	1,254
British India	6	2,304
Other British possessions	5	721
Total to British possessions ..	30	4,279
Total	106	20,109

❧

Wireless Telegraph Station in Brazil.

THE Brazilian Government is taking measures to erect a wireless telegraphy station, which will probably be the largest in South America. The contract for the post has already been awarded to the new Carpentier-Gaiffe-Rochefort firm of Paris, after a competition with the Marconi and the Telefunken Companies. As it is to be erected on the island of Fernando Noronha, it has a most favourable position, and commands the region to the north-east of Pernambuco and the leading Atlantic centres. It is to have a wide range of 1000 nautical miles, this being the least range; but in favourable weather this will be much increased and also during the night, when it is expected to connect across the Atlantic with the French African post at Levrier Bay in Senegal, at 1800 miles distance. It will also work with a smaller post located at Pernambuco itself, and will thus double the submarine cable between Pernambuco and the island. The new plant will use an antenna, carried on four large iron towers, these being of 230ft. height, and the four towers form the corners of a square, which has 520ft. on a side. The station lies in the centre of the square, and it will be fitted with a 60 horse-power apparatus, using a large storage battery in this connection. It is expected to have the new station completed and in running order about the end of this year.

* * *

The Sémat Photo-Telegraph.

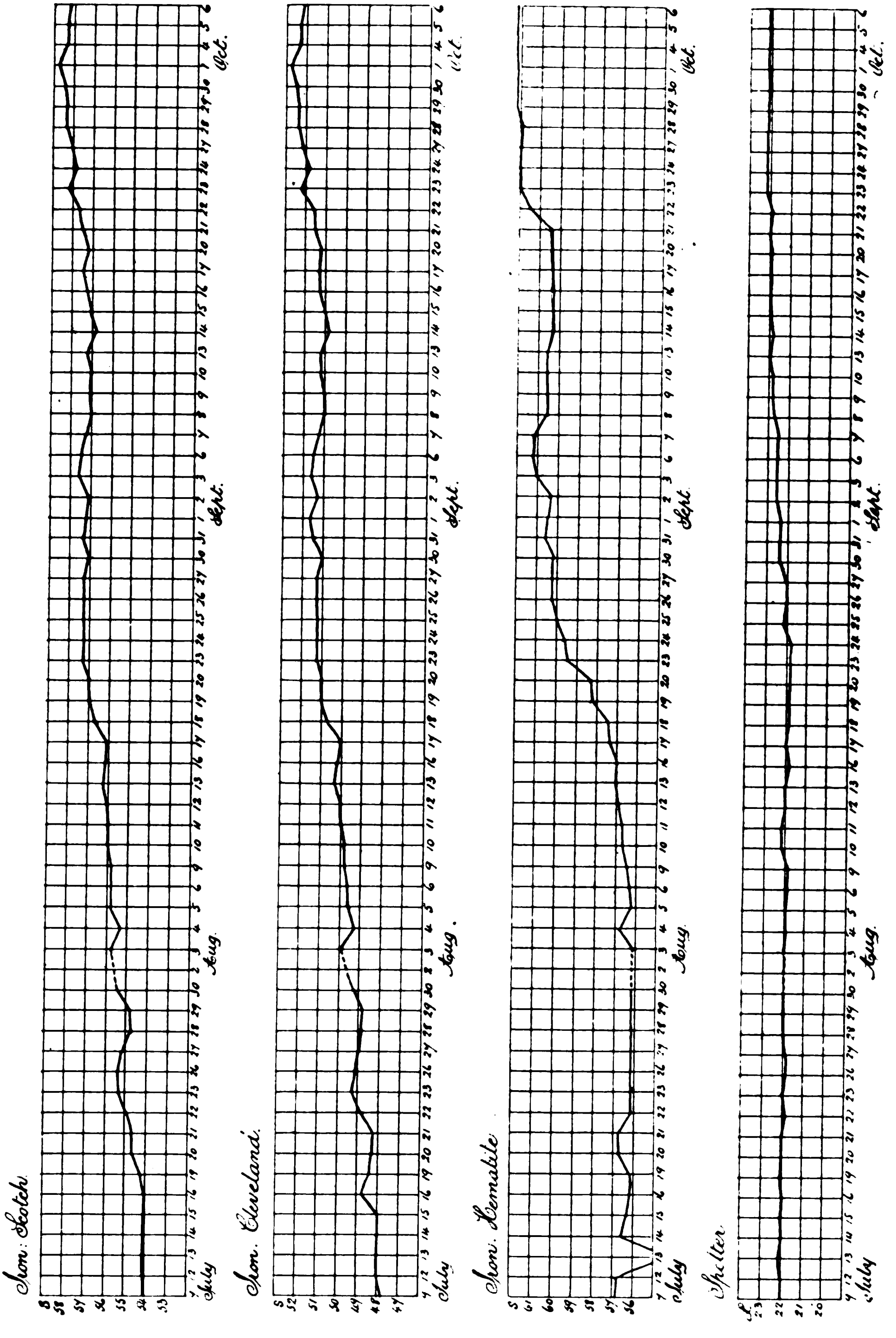
At the recent annual exhibition of the French Physical Society the apparatus lately invented by Laurent Sémat for the electric transmission of handwriting, drawings, photographs, &c., to a distance was shown at work. Up to the present one of the most difficult problems with all photo-telegraphy systems has been the securing of absolute synchronism between the sending and receiving stations. In the Sémat apparatus this has been solved in an ingenious and simple manner. The sending cylinder is of smaller diameter than the receiving cylinder, but both are of the same length, if the picture is to be reproduced in the original size, and both rotate at the same peripheral speed. A sheet of metal foil, on which the picture to be transmitted has been drawn or printed, is wound on the smaller diameter sending cylinder, covering its entire surface. A contact-making stylo bearing on the foil sends current impulses into the line, by means of which the picture is reproduced, the circuit being closed when the stylo is in contact with the foil and opened when it passes over the blackened parts. A sheet of carbon paper, and over the same a sheet of ordinary paper, is wound on the larger receiving cylinder. Assuming the difference in the circumference of the cylinders to be one-eighth, then the reproduced picture must cover only seven-eighths of the surface of the larger cylinder. The relations in the speed between the two cylinders are such that the smaller one will perform one revolution in seven-eighths of the time required by the larger one. The former stops after each revolution and starts again when the larger one has completed its revolution; that is, when it has moved the distance of one-eighth of its circumference left free by the picture. This operation is repeated at each revolution. By starting at the same point equal surfaces of both cylinders will pass under each stylo during the same time interval, the lateral displacement of both cylinders being the same, when reproducing pictures in original size. The advantages of Sémat's apparatus consist in the simplicity and perfection of the synchronising arrangement. Furthermore, no selenium or photo-sensitive plates or films are used, and all operations take place in daylight by means of mechanical devices. The instruments may be connected to ordinary telegraph or telephone lines, and a picture seven by twelve centimetres in size can be easily transmitted in five minutes.

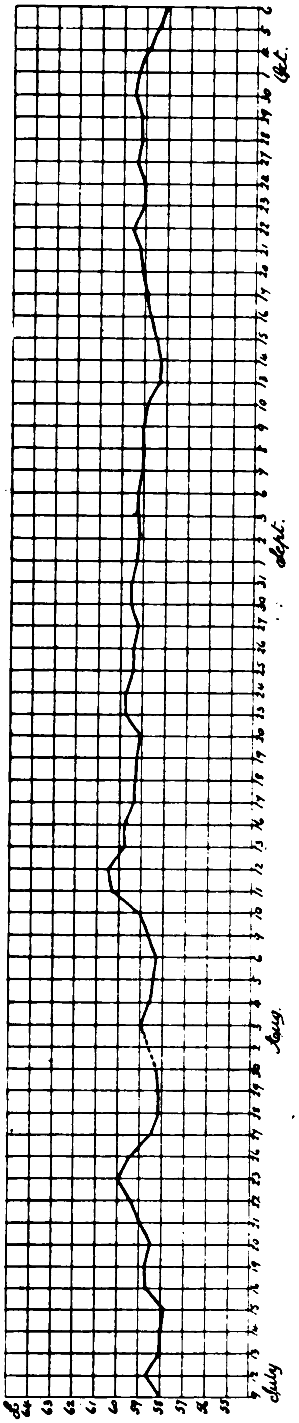
* * *

"Thorium Flint."

An alloy of iron and thorium which possesses remarkable properties has been produced by Mr. Welsbach, the well-known inventor of the incandescent gas mantle and other "rare earth" products. When struck lightly against a piece of iron this alloy emits exceedingly bright sparks, and sufficient heat is developed to ignite tinder instantaneously without the repeated efforts required with the old-fashioned flint and steel. The new material, which has been aptly termed "thorium flint," may be called an everlasting match, and will undoubtedly be very useful to explorers and tourists and for the ignition of explosives.

Home Market Metal Prices for the Past Three Months.





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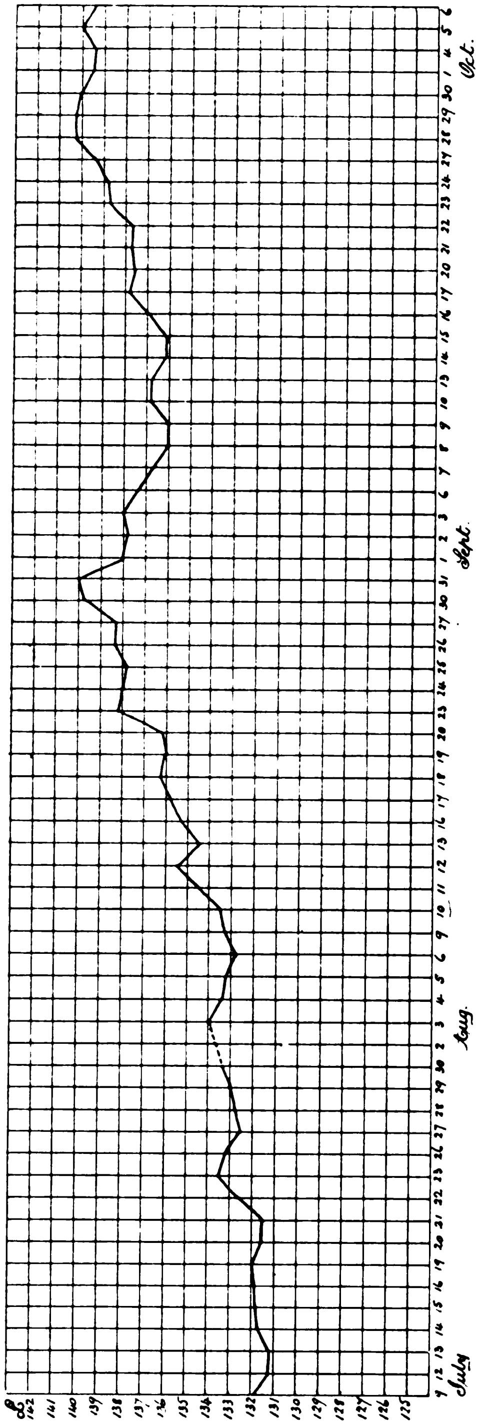
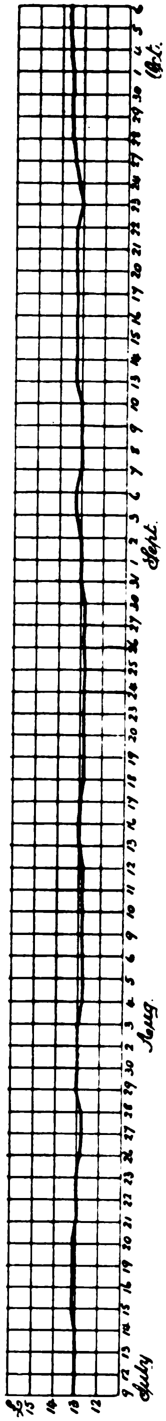


Tin.



Lead: English.

Machine Wave-Forms and Transmission Efficiencies.

In an Austrian contemporary a writer describes a case in which differences in the wave-form of two electrically connected synchronous machines resulted in considerable losses. Energy was transmitted from a large central station by three-phase current at 5000 volts to substations. The central station was originally a direct-current station, and during the time of the change to three-phase working a motor-generator transforming from direct current to three-phase current was installed. The three-phase generator of this set produced three-phase current at 5000 volts, which was transmitted to a three-phase, direct-current motor generator set in the substation. Both sets were exactly identical in construction and electrical design, since after the change of the central station was completed it was intended to install the power-house set also in the substation. The rating of both was 100kw. The efficiency of the transformation of direct current to three-phase current and of the transformation from three-phase current to direct current was found to be 84 per cent. in each case.

At normal load—200kw.—and with correct magnetising current the power factor was unity. After this plant had been in use for one and a half years the new three-phase station could be started and the set became superfluous in the central station. The substation was now connected to a steam-driven three-phase generator in the central station. It was then found that the efficiency of transformation from three-phase to direct current of the substation set had been reduced to 79 per cent. Moreover, it was no longer possible to get a unity power factor. It was found that this was due to the difference in wave-forms of the three-phase machines. The motor side of the substation set had three and the alternator two slots per phase and pole. The losses of the company on this account corresponded to the interest on a capital of about £2000.

Power Consumption of Reversing Rolling Mills.

At the meeting of the Iron and Steel Institute in London last month Mr. C. A. Ablett read a paper dealing with the costs of driving reversing rolling mills by electric motor. This is a subject of extreme interest at the present time to steel-works engineers, and the figures given will be of value to the many firms who are contemplating changes in this direction. The author mentioned that since the last autumn meeting of the Institute five steel works had decided to adopt electrically-driven reversing rolling mills, and twelve such plants are now at work in different parts of the world. The claims advanced on behalf of the electrically-driven mill are (1) greater economy in fuel consumption; (2) larger output from plant; (3) reduced running costs; (4) lower management expenses; and (5) the lasting economy of the plant. Although the capital cost of an electrically-driven reversing mill is greater than that of a steam-driven mill, worked by a plain two-cylinder engine, the cost has been reduced to a point where, unless an entirely new method is evolved in place of the Ilgner fly-wheel system, no further reduction in capital expenditure can be expected. In a very large number of cases, however, the economies following the adoption of electric driving are found to justify the increased capital expenditure. At the present time attention is focussed on the saving in fuel consumption, the advantages in the direction of increased output not being yet properly recognised by steel makers. The ordinary methods of making tests to determine the economy of a reversing engine are open to various objections. The energy consumption of an electrically-driven reversing rolling mill, as expressed in kilowatt hours per ton, can, however, be determined in the simplest possible manner by inserting an ordinary integrating wattmeter in the supply system, and taking regular readings. The efficiency of the electrical plant can also be checked in the simplest possible manner by placing a second integrating wattmeter in the armature circuit of the mill motor. The figures given below were cited by the author as being characteristic values of the kilowatt hours per ton rolled obtained from tests on reversing mills :—

	kw. hours per ton.
4½in. by 4½in. billets from 2.5-ton ingots. Output, 53 tons per hour	22.5
6in. by 6in. blooms from 2.5-ton ingots. Output, 63 tons per hour	17.5
8in. by 8in. blooms from 2.5-ton ingots. Output, 80 tons per hour	13.0
12in. by 9½in. blooms from 7-ton ingots measuring 34½in. by 25in. Output, 65 tons per hour	11.2
32in. by 9in. slabs from 6-ton ingots measuring 36in. by 19½in. Output, 40 tons per hour	4.3
32in. by 5in. slabs from 6-ton ingots measuring 36in. by 19½in. Output, 40 tons per hour	5.8
Flange rails, 100lb. per yard, from 2-ton ingots. Output, 30 tons per hour	48.0
Beams, 120lb. per yard, from 1.5-ton ingots	36.0
Channels, 92lb. per yard, from 1.5-ton ingots	37.0

* * *

Chromium and Tungsten Ores in Canada.

Two important publications relating to the mineral wealth of Canada have been recently issued by the Mines Branch of the Department of Mines at Ottawa.

In the last few years, owing to the rapid development of the iron and steel industry in Canada, more than ordinary interest has been manifested by the mining and metallurgical public in respect to the Canadian deposits of raw materials and ores which enter into the manufacture of iron and steel products. To meet the demand for information on these subjects the Mines Branch has undertaken to issue a series of reports on the Canadian deposits of the substances which form the basis of the iron and steel industry. Several reports on iron ores, &c., have already been issued, and these reports are the latest of the series.

They deal respectively with the occurrences and nature of chromium and tungsten ores. The first is a "Report on the Chrome Iron Ore Deposits of the Eastern Townships," by Fritz Cirkel, M.E.

The scope of this report may be well judged by quoting the Table of Contents, which is as follows :—Historical ; The Chrome Iron Ore Deposits of Canada ; Mining of Chrome Iron Ore ; Dressing for the Market ; Market Prices and Status of the Canadian Industry ; Chrome Iron Ore Mines—Prospects in Canada ; Chrome Iron Ores in Foreign Countries ; Origin ; Composition of Chrome Iron Ores ; Statistics and Chronology ; Determination of the Value of Chromium ; Uses of Chromium ; Technology of Chromium and its Compounds ; Experiments with Chromite at McGill University ; Bibliography.

The report is well illustrated by eleven plates in half-tone from photographs of mines, mills and machinery ; and fifteen diagrams, maps, and drawings, all illustrative of the chromite industry. The author of the report, Mr. Fritz Cirkel, Mining Engineer, has had a long connection, as consulting engineer, with the chromite and the asbestos industries. The deposits of these two substances in the province of Quebec occur in the same region, and the origin of both is closely connected with the serpentine rocks of the eastern townships. The book will form a welcome addition to the library of the mining engineer, the metallurgist, and the capitalist interested in the iron and steel industry. Moreover, it may be pointed out that the chapters on the uses, the technology, and the metallurgy of chromium and those on the origin and the composition of chrome iron ores, as well as the bibliography, will be appreciated by all students and investigators on the subject of chromium and chromite.

The tungsten ores of Canada are dealt with in a very comprehensive illustrated report by Professor T. A. Walker, of Toronto University. As is well known, the element tungsten has lately become vastly important to engineers. Electrical men know it as the essential of the metallic filament lamp, which, with its brilliant light and great efficiency, is already advancing electrical interests by leaps and bounds. Of the greatest importance also is the use of tungsten in the manufacture of tungsten-steel, to which it imparts great elasticity and tensile strength. The known occurrences of tungsten ores throughout the world are comparatively few, which fact lends additional interest to some discoveries of scheelite (an ore of tungsten) which have been made within the past year or two in Nova Scotia. These, together with other occurrences of tungsten ores in Canada, form the subject of the present report, which is claimed to present to those interested all the available information on these ores.

The several occurrences of tungsten ore in Canada are described in detail, and a general statement is given on the geological occurrence of the ores, chemical tests, concentration, the uses of the metal, producing mines in other countries, statistics of the world's production, &c., while a very useful bibliography of the literature on the Canadian and United States occurrences is added. The report covers in all some fifty-six pages, and with the aid of fifteen illustrations presents an account of what can but be classed as an important potential mining industry of the Dominion.

◆

Marine Propulsion by Producer-Gas.

An American contemporary, "International Marine Engineering," publishes some noteworthy results of the operation of a small boat fitted with a producer-gas plant and having a reversing engine directly connected to the propeller. This boat, the *Marenging*, is 40ft. long, 9ft. wide, and has a draught of 3ft. 6in. Its average speed is from eight to nine miles an hour. The engine used for the producer-gas trial runs was an ordinary four-cycle, four-cylinder petrol engine, with cylinders 5¼in. in diameter by 6in. stroke, and, running at 400 to 500r.p.m., drives a 24in. three-blade screw propeller. The petrol engine was modified to run with much higher compression than for petrol service, but no modifications were necessary in the piping, admission, or exhaust valves, these being deemed amply large enough for the engine operating with gas. With regard to the degree of compression, this was only carried up to 100lb. per square inch, whereas 150lb. per square inch is quite a feasible pressure, and consequently the results obtained are not so good as might be expected with a properly-designed engine for the gas service.

Because of the inadequacy of the engine no attempt was made to carry out tests involving extreme refinement. The results obtained do show, however, that marine producer-gas plants can be successfully operated with remarkable economy. Compared with a steam-power plant, this boat has shown remarkable economy, averaging a horse-power an hour on slightly over a pound of coal. In regular service the boat covers between 800 miles and 900 miles on a ton of anthracite pea coal, costing between 14s. and 21s. This amount of coal covers the banking of fires and starting up at frequent intervals.

If the boat were started out on a continuous run it is believed that it would make practically a thousand miles on a ton of coal. Such a non-stop run was attempted on July 9, the boat leaving New York for a trip up the Hudson River to Albany and back—a distance of 275 miles. Unfortunately, considerable trouble was encountered in navigating the boat in certain parts of the river during the night, as large quantities of eel grass and weeds grow near the sides of the channel, in which the propeller became fouled a number of times, causing unavoidable shut-downs. Two such mishaps on the way to Albany delayed the boat for from ten minutes to an hour each time. Similar trouble was experienced on the return journey, preventing a non-stop run. The results, even allowing for the shutting down of the engine and banked fire, show remarkable fuel economy, as will be seen from the following data :—

Total mileage	275
Pounds coal burned to Albany	351
Pounds coal burned to New York	285
Total pounds coal burned for trip	636
Time to Albany	22 hours 42 minutes
Time to New York	18 hours 43 minutes
Time for entire trip	41 hours 25 minutes
Pounds of coal burned per mile to Albany	2.55
Pounds of coal burned per mile to N. Y.	2.07
Pounds of coal burned per mile entire trip	2.31
Pounds of coal burned per hour to Albany	15.45
Pounds of coal burned per hour to N.Y.	15.20
Pounds of coal burned per hour entire trip	15.32

One of the principal objects in view when this boat was brought out was to demonstrate to the owners of coasting schooners in the lumber, coal, and other trades, also to the owners of fishing boats, oyster boats, and owners of yachts requiring less than 500h.p., the fact that producer-gas has many striking advantages over either steam or petrol. A producer-gas plant can be installed on a fore-and-aft-rigged vessel at small expense, and can be operated at very slight cost. The cost of operation with anthracite coal costing about 16s. per ton, as shown by tests made on the *Marenging*, is practically one-tenth of what the cost would be if petrol were used at a price of 7½d. per gallon.

As compared with a steam plant, the producer-gas plant, judging from the results obtained with this boat, shows a decided increase in economy over a steam plant, since a horse-power hour can be obtained from slightly over one pound of coal; whereas in the ordinary tugboat using high-pressure steam it is doubtful if a horse-power hour is obtained with much less than five pounds of coal. On large steamships and warships a steam-power plant shows, of course, better economy than a tugboat, a horse-power an hour being obtained on an average of from 1¾lb to 2lb of coal. A saving of from 25 to 50 per cent. in such plants, however, means a large sum of money. Another advantage is the ease of operation. Any man who can take proper care of an internal-combustion engine can, without any difficulty whatever, manage a producer-gas plant.

❧

Automatic Typewriting. By the courtesy of the Underwood Typewriter Co. we were privileged to inspect at their City offices an extremely interesting automatic machine prior to its removal to Olympia, where at the Business Exhibition it will undoubtedly prove to be one of the most popular exhibits. The new machine is quite a distinct departure in that it performs automatically those duties in the way of typewriting which have always proved to be desirable and yet expensive in commercial correspondence and publicity work, so that it is not only interesting as a highly ingenious mechanical invention, but it is likely to prove a very valuable commercial commodity. In general we may say that it is essentially another application of the principle which has been so successfully employed in automatic piano-players. The pneumatic principle has been adapted to work an ordinary typewriter. The machine consists of a small electrically driven bellows, the motor in this case being of ¼h.p., although we were told that the standard requirement is ⅛h.p. The bellows provide air for a number of small pneumatic motors, of which one is provided for each key or motion of the typewriter. The electric motor also serves to drive the perforated roll which carries the record of the letter or MS. which is to be typewritten. As will be understood, there would appear to be no great difficulty in applying this electro-pneumatic principle to the operation of a typewriter; it is only when one comes to consider the details that the beauty of design embodied in this machine is apparent. The typewriter, for instance, is fitted with such a fine escapement that it operates regularly at a speed of writing of 200 to 250 words per minute, and this it does with perfect accuracy, the shift keys and tabulation being brought in with the precision of an ordinary good typewriter manually operated at low speeds. Moreover, the new machine is self-feeding, a stock of paper being placed in a carrier on one side from which it is automatically taken sheet by sheet, fed into the machine, typewritten, and discharged into a corresponding receiver on the other side of the machine. Consequently the machine requires no attendance whatever when at work, the motor simply being switched on, and the machine left to make as many "original" copies of the letter or circular as may be desired.

Probably the most important and advantageous feature of the machine is that it not only gives an original typewritten letter or circular to any amount, but each letter or circular can at the same time be fitted with distinct names, addresses, &c. This is done by having a duplicate record roll containing the addresses. As each letter is completed a change-over switch is automatically operated bringing the address record into action. When the address is written this key changes over and the letter record is brought in. Thus absolutely complete letters or circulars are turned out by the machine, and the trouble of having to insert individual addresses which now obtains with the usual imitation typewritten letter—whether it be set in printer's type or of the Roneo or cyclostyle form—is obviated. Space and time preclude our giving further particulars and mechanical details of the machine at this writing. We hope, however, to do so in our next number.

Another feature of the Underwood Company's exhibit which will prove a great attraction will be the speed typewriting of Mr. Emil Trefzger, who, if we may put it so, will be an exhibit of the perfection of manual typewriting. As we saw for ourselves, Mr. Trefzger is almost an automaton also so far as typewriting is concerned. For instance, he copied from a book matter quite new to him at a rate of some 120 words per minute, maintaining meantime quite an interesting conversation on a different subject altogether. We understand that he is to compete for the speed and accuracy competition at the Exhibition, and readers will doubtless hear more of his prowess in that direction.

* * *

OSRAM LAMPS
THE LIGHT FOR ALL
WONDERFUL!-20 HOURS FOR ONE PENNY!

The above is a reproduction of a show-card recently produced by The General Electric Company, Ltd., in connection with the Osram Lamp sales department.

THE
ELECTRICAL MAGAZINE
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JIGS AND JIG DESIGN.

UNDOUBTEDLY one of the most important features in the preparation of the necessary small tools and accessories for machine manufacture is that of the design of suitable jigs and fixtures.

This is particularly true with regard to workshops engaged in mass production or repetition work. Possibly there are still many engineering concerns engaged in work of so varied and general a character as would prohibit the extensive use of jigs in their machine shops, owing to the initial cost and multiplicity of the jigs required.

Here it may be mentioned for the benefit of those who may not be familiar with workshop vernacular that the term "jig" is a general one, and is usually understood to include all appliances designed with the object of fixing and locating work preparatory to any process of machining. The term "fixture," which is no doubt of American origin, is intended to specify those appliances which are bolted or "fixed" to the bed or table of a machine tool. Examples under this head include appliances for milling, planing, slotting, shaping and grinding operations. On the other hand there are those appliances which both locate the work and guide the cutting tool. Examples under this head include drilling jigs, filing jigs, &c. Drilling jigs, as a general rule, need not be clamped down and are easily held in position by hand, so that it would be absurd to call such a device a "fixture."

The exact distinction, however, with some jobs is not always very clear, and since it is not a matter of vital importance it is the writer's practice to use the term jig for drilling appliances only, all other types being christened fixtures.

The importance of jigs and fixtures has of recent years become more and more recognised, and many firms who were formerly engaged on general work have started on one or two special lines of machine manufacture in order that they might the better cope with the strenuous competition in trade which is such a feature of modern manufacturing.

By limiting the range of work engaged upon these firms are enabled to produce their specialities on the soundest and most economical lines, by the proper use in their workshops of special jigs, tools, and other labour-saving appliances. The flourishing condition of firms thoroughly equipped in this respect proves beyond all doubt the superiority of their methods.

For interchangeable work, where component parts are manufactured so as to fit with certainty when supplied for replacement, jigs and fixtures are of course

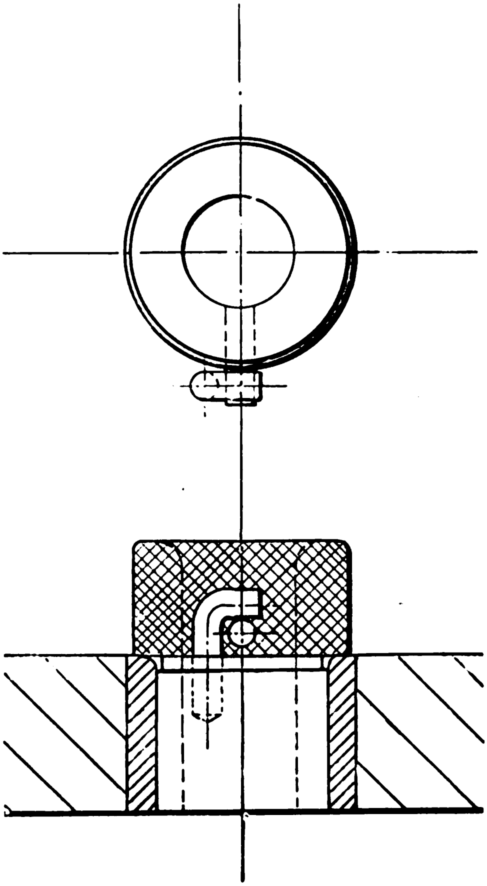


FIG. 1. ARRANGEMENT OF MOVABLE BUSHING.

indispensable. In ordinary manufacturing jigs are used with one or more of the following objects in view:—

1. Elimination of marking off or setting out work previous to machining operations.

2. Reduction of the actual time of machining operations and reduction of time spent in fixing the work.

3. Greater degree of accuracy and uniformity of work.

4. Reduction of cost of subsequent operations, such as fitting, erecting, &c.

5. To facilitate replacement of broken or worn-out parts.

6. Reduction of skill required to perform the various operations on the work and to permit of placing a workman at a cheaper rate on the job than would be possible with ordinary methods.

It is obvious that the results coming under headings Nos. 1, 2, 4, and 6 constitute direct factors in the actual cost of production of the particular article dealt with, and in the majority of cases the economies effected repay in a very short time the cost of the required jigs.

It must not, however, be supposed that jigs are necessary for each and every job to be dealt with; indeed, there are many cases where one can dispense with a jig altogether and still obtain the best results as regards economy in production and satisfactory finish.

Take, for example, a simple cast-iron treadle lever; possibly the only machining necessary is a plain hole in the boss for a fulcrum pin with no particular reference to any part of the lever save that it must be fairly central with the boss. In this case it would be absurd to construct a jig, however simple, to hold the work or guide the drill. With such work it is a common practice with some firms to prepare the pattern in such a manner that it leaves the face of the boss spotted or centred with a rough centre mark in the casting, so as to provide a ready means of starting and locating the drill without marking out, the work being held by hand in the usual way, and in such a case no jig is required.

Another consideration underlying the question as to whether or not to make a jig when fixing on the method of machining any particular article is that of the number of pieces required. If the model of the piece to be operated upon should be subject to frequent and unavoidable alterations the cost of jigs would probably outweigh the economies effected. This question is one that frequently arises and should be carefully considered in all cases. It is the practice in some establishments not to make jigs or fixtures unless it is estimated that their cost may be saved within a certain length of time. Naturally the period fixed upon varies according to the whims and fancies of individuals, but it is certain that each piece of work should be considered on its own particular merits by some person thoroughly acquainted with what savings may be effected by various methods; and if the nature and quantity of the work promise a saving which will pay for the outlay on jigs and tools within a reasonable length of time, then the work of constructing the appliances should be proceeded with.

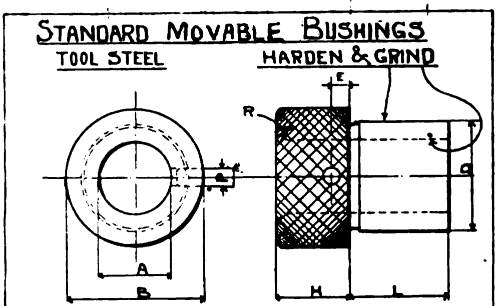
The jig designer should be thoroughly acquainted with workshop methods and practice, the basis of his training being a complete knowledge of the ordinary methods of machining component parts; for the jig itself merely consists of a special method of fixing the work whereby the amount of time and skill necessary to fix and locate the work is reduced to a minimum, and the amount of time necessary to perform a given amount of work reduced as much as possible through the medium of special devices on the jig, or by some particular method of arranging the work on the jig.

Having decided to make a jig, the first question should be as to whether the casting is in its most suitable form for operating upon, for it frequently happens that a very slight alteration in the form of a casting or forging will make a considerable difference in the cost of production of a given piece of work, and will often simplify to a great extent the problem of fixing and locating the work. It might here be mentioned that the co-operation of the pattern shop and foundry should be encouraged, since castings are frequently located in the jigs from their rough surfaces, so that careless pattern-making and rough or badly-dressed castings cause a great amount of trouble in the machine shops.

The next point to be decided upon is the relation the various machined parts bear to one another or to some other part or parts of the machine to which they belong. This being clear, the question of the order of the required operations should be fixed upon, *i.e.*, whether cylindrical or flat surfaces should be performed first. As a general rule planing or milling, as the case may be, is considered the first process; in some cases, however, it may be found more convenient to perform drilling or boring operations first, according to circumstances.

The various points to be considered with reference to the design of the jig or fixture

STANDARD MOVABLE BUSHINGS

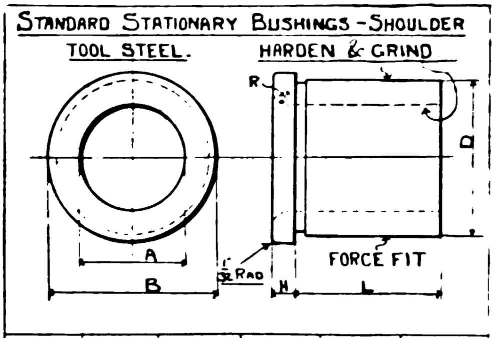


FOR ODD REAMING AND TAPPING SIZES THE OUTSIDE DIMENSIONS GIVEN FOR THE NEAREST SIZE STANDARD HOLE SHOULD BE USED

A Dia of Hole	B	D	H	L	R	P	E
3/16	13/16	7/16	5/8	5/8	1/8	3/16	3/16
1/4	7/8	1/2	5/8	5/8	1/8	3/16	3/16
5/16	15/16	9/16	5/8	5/8	1/8	3/16	3/16
3/8	1 1/16	11/16	5/8	11/16	1/8	3/16	3/16
7/16	1 1/8	3/4	5/8	11/16	1/8	3/16	3/16
1/2	1 3/16	13/16	5/8	11/16	1/8	3/16	3/16
9/16	1 3/8	7/8	5/8	11/16	5/32	3/16	3/16
5/8	1 1/2	1	5/8	11/16	5/32	3/16	3/16
11/16	1 9/16	1 1/16	5/8	1	5/32	3/16	3/16
3/4	1 5/8	1 1/8	3/4	1	5/32	3/16	3/16
13/16	1 11/16	1 3/16	3/4	1	5/32	1/4	1/4
7/8	1 3/4	1 1/4	3/4	1	5/32	1/4	1/4
15/16	1 7/8	1 3/8	3/4	1	3/16	1/4	1/4
1	1 15/16	1 7/16	1	1 1/4	3/16	1/4	1/4
1 1/8	2 1/8	1 5/8	1	1 1/4	3/16	1/4	1/4
1 1/4	2 1/4	1 3/4	1	1 1/4	3/16	1/4	1/4
1 3/8	2 3/8	1 7/8	1	1 1/4	3/16	1/4	1/4
1 1/2	2 1/2	2	1	1 1/2	3/16	5/16	5/16
1 5/8	2 7/8	2 1/4	1 1/8	1 1/2	1/4	5/16	5/16
1 3/4	3	2 3/8	1 1/8	1 1/2	1/4	5/16	5/16
1 7/8	3 1/4	2 5/8	1 1/8	1 1/2	1/4	5/16	5/16
2	3 3/8	2 3/4	1 1/8	1 1/2	1/4	5/16	5/16

FOR HOLES UP TO 5/16 DIA LEAVE ·002" FOR LAPPING OUT
FOR HOLES 5/16 UPTO 5/8 DIA LEAVE ·005 FOR GRINDING OUT
FOR HOLES 5/8 UPTO 1" DIA LEAVE ·01 FOR GRINDING OUT
FOR HOLES 1" AND OVER LEAVE ·015" FOR GRINDING OUT

FIG. 2.



A	B	D	L	H	R
3/16	9/16	7/16	5/8	1/8	3/16
1/4	5/8	1/2	5/8	1/8	3/16
5/16	11/16	9/16	5/8	3/16	3/16
3/8	13/16	11/16	13/16	3/16	3/16
7/16	7/8	3/4	13/16	3/16	3/16
1/2	15/16	13/16	15/16	3/16	3/16
9/16	1 1/16	7/8	15/16	3/16	3/16
5/8	1 3/16	1	15/16	3/16	3/16
11/16	1 1/4	1 1/16	1	1/4	3/16
3/4	1 5/16	1 1/8	1	1/4	3/16
13/16	1 3/8	1 3/16	1	1/4	1/4
7/8	1 7/16	1 1/4	1	1/4	1/4
15/16	1 9/16	1 3/8	1	1/4	1/4
1	1 5/8	1 7/16	1 1/4	1/4	1/4
1 1/8	1 13/16	1 5/8	1 1/4	1/4	1/4
1 1/4	1 15/16	1 3/4	1 1/4	1/4	1/4
1 3/8	2 1/16	1 7/8	1 1/4	1/4	1/4
1 1/2	2 3/16	2	1 1/2	5/16	5/16
1 5/8	2 7/16	2 1/4	1 1/2	5/16	5/16
1 3/4	2 9/16	2 3/8	1 1/2	5/16	5/16
1 7/8	2 13/16	2 5/8	1 1/2	5/16	5/16
2	2 15/16	2 3/4	1 1/2	5/16	5/16

FOR HOLES UP TO 5/16 DIA LEAVE ·002″ FOR LAPPING OUT
FOR HOLES 5/16 UP TO 5/8 LEAVE ·005″ FOR GRINDING OUT
FOR HOLES 5/8 UP TO 1″ LEAVE ·01″ FOR GRINDING OUT
FOR HOLES 1″ AND OVER LEAVE ·015″ FOR GRINDING OUT

Fig. 3.

itself will now be taken, dealing with the most common types of jigs and fixtures.

Milling and Planing Fixtures.

All clamping devices should be instantaneous in action, and arranged so that the work is not distorted in cramping down. Wherever possible clamping devices should be through the medium of pin screws, wing nuts, or knurled-headed screws in preference to nut or screws and spanner. The time spent on looking for and handling spanners is too precious to waste, and quick tightening arrangements are necessary for rapid operation. Heel cramps should be made with elongated holes for the bolts, so that they may be drawn clear of the work when putting the work in and out of place. The cramps should also be supported by spiral springs to hold them in working position. Loose parts should be carefully avoided, as they invariably get mislaid or lost altogether. Sometimes, however, small loose parts are necessary, and in such cases it is better to connect them to the main frame of the jig or fixture by means of a light chain. Fixtures should all be made sufficiently weighty to absorb the vibration due to the action of the cutting tool, and stiff enough to withstand the tendency to twist or buckle when cramping down the work. Difficulties in machining the fixture itself often arise, owing to complications in the design. In such cases the problem can always be solved by resorting to a built-up construction with loose parts which can be fixed in place after machining. Milling fixtures should be arranged with clamps and tightening arrangements well clear of the surface to be operated upon, so as to ensure the use of as small a milling cutter as is possible.

Drilling Jigs.

These may be made much lighter than milling fixtures as a general rule, since there is nothing like the same stress in the various portions of the jig due to the cutting action of the drill as compared with the cutting action of the milling cutter or planing tool. The jig should be sufficiently stiff, however, to withstand a reasonable amount of rough usage.

Sometimes the drill jig takes the form of a simple plate or disc which is located by pins and clamped to the work itself; the plate is provided with holes which correspond in diameter, position, and number to those required in the work. The cheapest method when the plate is small is to have a plate of steel and harden it, so as to avoid the expense of bushing. With larger sizes of plates it is customary to form the plate of cast-iron or mild steel and fit it with hardened steel bushings for the holes.

Leaf Jigs.

A common form of jig for drilling small articles is one generally known as the "Leaf Jig." It consists of a light base-plate carrying the article or articles to be drilled, which are located by pins; hinged to the base-plate is an upper plate or "leaf" carrying the drill bushings in the correct position relative to the work. The top and bottom plates are each provided with a handle arranged so as to be conveniently gripped by the hand, and by means of which the work is firmly clamped between the top and bottom portions of the jig when drilling. With the object of obtaining greater production, the leaf jig can often be used on light work in conjunction with a multiple drilling attachment. Given, say, a four-spindle drilling attachment, the four articles to be drilled are placed in a suitable leaf jig and all drilled at one stroke of the spindle.

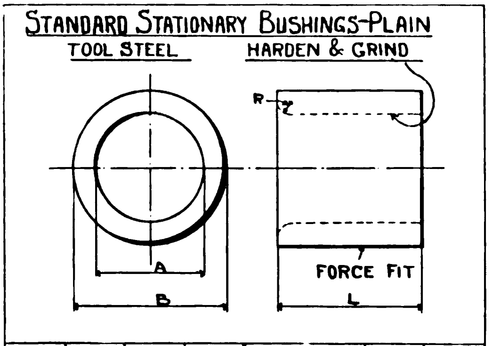
Box Jigs.

These constitute another common type of jig. They are for use on pieces in which holes are drilled from two or more sides. The box consists of a skeleton framework in which the work is located and cramped by the usual devices, and which is capable of supporting the work in the correct positions for the various holes required.

Other types of drill jigs consist simply of a base or framework to which the work is cramped in the required position for drilling; whilst the drill guide bushes are usually carried by a plate arranged so as to stand just clear of the portion to be drilled, the plate being screwed down and fixed in its correct position by dowel pins. In many cases there are difficulties in getting the work readily in and out of place, but in such cases a hinged bush plate will ofttimes form a solution to the problem. All jigs should be arranged so as to be readily cleared of chips, whilst all clamping devices, &c., should be fixed so that the drill chuck may be brought down as close to the work as possible in order that the shortest of drills may be used on the work.

Stationary Drill Bushings.

For ordinary standard holes a permanent steel bush is used on jig work to guide the point of the drill. In order to provide against shrinkage and warping due to the subsequent process of hardening, the bushes are left $\frac{1}{64}$in. large on the body portion

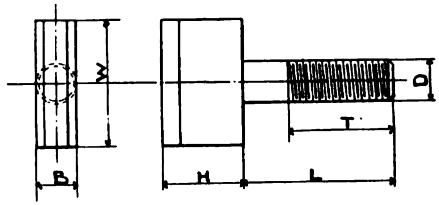


A	B	L	R	A	B	L	R
1/16	1/4	1/2	3/32	1	1 7/16	1 1/4	3/16
1/8	5/16	9/16	3/32	1 1/8	1 5/8	1 1/4	3/16
3/16	7/16	5/8	1/8	1 1/4	1 3/4	1 1/4	7/32
1/4	1/2	5/8	1/8	1 3/8	1 7/8	1 1/4	7/32
5/16	9/16	5/8	1/8	1 1/2	2	1 1/2	7/32
3/8	11/16	13/16	1/8	1 5/8	2 1/4	1 1/2	1/4
7/16	3/4	13/16	1/8	1 3/4	2 3/8	1 1/2	1/4
1/2	13/16	13/16	1/8	1 7/8	2 5/8	1 1/2	1/4
9/16	7/8	13/16	5/32	2	2 3/4	1 1/2	1/4
5/8	1	13/16	5/32	2 1/8	2 7/8	1 7/8	1/4
11/16	1 1/16	1	5/32	2 1/4	3	1 7/8	1/4
3/4	1 1/8	1	5/32	2 3/8	3 1/4	1 7/8	5/16
13/16	1 3/16	1	5/32	2 1/2	3 3/8	1 7/8	5/16
7/8	1 1/4	1	5/32	2 5/8	3 1/2	2 1/8	5/16
15/16	1 3/8	1	5/32	2 3/4	3 5/8	2 1/8	5/16

FOR HOLES UP TO 5/16" DIA LEAVE ·002" FOR LAPPING OUT
FOR HOLES 5/16" UP TO 5/8" LEAVE ·005" FOR GRINDING OUT
FOR HOLES 5/8" UP TO 1" LEAVE ·01" FOR GRINDING OUT
FOR HOLES 1" AND OVER LEAVE ·015" FOR GRINDING OUT

FIG. 4.

STANDARD QUICK RELEASING JIG SCREWS.



D	THREADS	L	T	W	H	B
5/16	18	1 1/2	1	1 1/8	3/4	5/16
3/8	16	1 5/8	1 1/8	1 1/4	3/4	3/8
7/16	14	1 5/8	1 1/8	1 3/8	7/8	7/16
1/2	12	1 3/4	1 1/4	1 1/2	7/8	1/2
5/8	11	1 3/4	[illegible]	1 5/8		5/8

FIG. 5.

for letting into place, whilst an allowance of .002in. to .015in., according to the diameter of the hole, is made for lapping or grinding out to correct size.

Stationary bushings are made in two styles, viz., the plain bush and the bush with a shoulder at the upper end. The plain bush is used only where it is necessary to have the top of the bush standing below or level with the surface of the jig, an objection to this form of bushing being that it is easily shifted out of its position if the drill is brought down carelessly or bumped down on to the bush. In order to obviate this evil the shouldered bush is used whenever possible.

Movable Bushes.

In many instances movable or loose bushes are required, say, for example, when the work is drilled and reamed, drilled and tapped, or when two holes of different sizes are required at the same point, but one above the other, at the same setting.

When drilling and reaming at one setting, that portion of the jig carrying the bush is first fitted with a plain stationary bush, which is bored to receive the movable bushes. The first movable bush is bored to suit the reamer drill, *i.e.*, with the required allowance less than the finished size of the hole required, whilst the second movable bush is bored out and ground to the finished size (see Fig. 1).

Another method which serves the purpose sufficiently well for general work is to use an ordinary permanent bush bored to suit the reamer. The work is first spotted with a drill fitting the bush in order to start the next drill true, the hole is then opened out with a smaller drill, leaving the required allowance for reaming, after which the bush guides the reamer in the ordinary way. By the above method the cost of two bushes is saved. All bushes should be made of tool steel, and carefully hardened and ground or lapped to size. Figs. 2, 3, and 4 give the writer's practice with reference to the usual forms of drill bushes. Referring to Fig. 1, it will be noticed that a simple knee pin is used to prevent the bush turning with the rotation of the drill, and at the same time it prevents the lifting of the bush on withdrawing the drill. This method is probably the cheapest and most effective form of stop, and at the same time gives plenty of latitude for a screwing-out motion when removing the bush. This latter point should not be overlooked, since it is sometimes a difficult matter to remove the bushes when they get warm and expand. For the same reason the collars are knurled and of ample proportions in order that they may be readily gripped by the operator.

When drilling and tapping at the same setting only one movable bush for the tapping drill is required, the bush being removed to give the necessary clearance for the tap.

Laying Out and Machining.

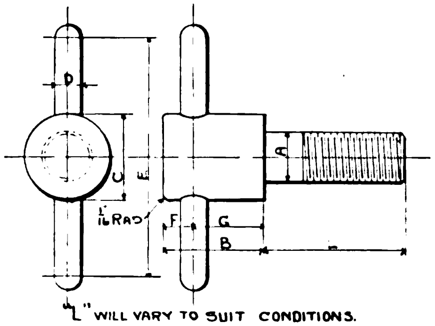
One of the most important features of jig manufacture is that of laying out and drilling the holes for the guide bushes. The first point to be considered in connection with this part of the work is that of the required degree of accuracy. In some cases the limit of error is very fine, and it is impossible to take too much trouble in setting out and machining this class of work. The degree of accuracy should be decided upon with due reference to the commercial and practical requirements of the work, but it is a common fault with small tool makers to waste valuable time in endeavours to produce finely accurate work when a comparatively rough job would suffice; and many firms waste large sums by rigidly adhering to some particular limit on jig work irrespective of the actual requirements of the work. In laying out and spacing the holes for drill jigs there are two ordinary methods of doing the work. The work may either be marked out in the usual way by circumscribing the hole and marking with a centre punch before drilling, or the work may be first marked out and then mounted in a lathe for drilling and boring out to the required size. The first method suffices for the ordinary run of work. It is, of course, a well known fact that owing to the lack of homogeneity in metals it is impossible to avoid what is technically known as the "running" or "wandering" of the drill, but, provided nothing finer than, say, a limit of error of .005in. is asked for, the method will produce satisfactory results. As a matter of fact, uniformity of production is more important as a rule than finely accurate work when once the jig is constructed.

If extreme care is taken with the work, holes may be drilled on the ordinary drilling machine within a limit of error of .003in., but nothing finer than this can possibly be expected by that method.

Finer work may be accomplished by the lathe method. The piece to be bored is first carefully marked out, and then clamped to the face-plate in the usual manner, care being taken to balance the plate if the disposition of the weight in the piece to be bored tends to cause vibration. After setting the circle true to a fine scriber point, the hole is first drilled to the approximate size, and afterwards opened out to the required size with a fine boring bar.

If exceptionally delicate work is required, it is usual to do the work on a special jig boring machine provided with vernier adjustments and readings, the machine being specially constructed and used solely for work of this nature.

STANDARD CLAMPING SCREWS.



"L" WILL VARY TO SUIT CONDITIONS.

A	B	C	D	E	F	G	THREADS
5/16	7/8	5/8	1/4	2 1/4	3/16	9/16	18
3/8	15/16	11/16	1/4	2 1/4	5/16	5/8	16
7/16	1	3/4	1/4	2 1/2	5/16	11/16	14
1/2	1 1/16	7/8	1/4	2 3/4	5/16	3/4	12
5/8	1 1/4	1 1/16	5/16	3	3/8	7/8	11
3/4	1 3/8	1 1/4	5/16	3 1/2	3/8	1	10

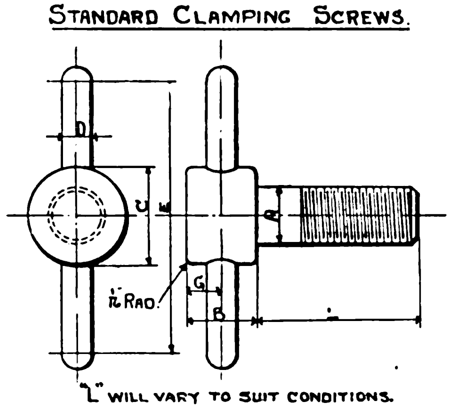
FIG. 6

Filing Jigs.

Filing jigs are used principally for forming the edges of flat steel pieces of irregular outline. The jig itself consists of a hardened flat steel templet, the outer size and form on the edge of which agree with those of the piece required.

The blank which is located relatively to the templet by means of pins is clamped together with the templet between the jaws of an ordinary vice. The edges to be operated upon are then cut down to size and shape by filing down to the hardened edge of the templet.

In some instances small work of the class described may be done more economically by this method than would be possible by machining. Filing jigs are also used to advantage when the quantity of work required is not sufficient to warrant the use of expensive formed milling cutters and



A.	B	C	D	E	G	THREADS
5/16	3/8	5/8	3/16	2 1/4	5/16	18
3/8	5/8	11/16	1/4	2 1/4	5/16	16
7/16	5/8	3/4	1/4	2 1/2	5/16	14
1/2	5/8	7/8	1/4	2 3/4	5/16	12
5/8	3/4	1 1/16	5/16	3	3/8	11
3/4	3/4	1 1/4	5/16	3 1/2	3/8	10

FIG. 7.

the construction of the more elaborate and expensive machining jig.

Jig Drawings and Records.

The necessary drawings for jigs and fixtures are usually prepared by a section of the drawing office staff specially engaged in the design of the necessary special tools for the economical production of the machines themselves. As a general rule jig drawings are not traced, the pencil drawing being sent into the tool room, and afterwards preserved as a record and for reference in connection with subsequent alterations, additions, or similar jobs. For small, unimportant, and odd jobs a hand sketch is considered all that is necessary, and for such work no record is kept.

Information of an important or special character with regard to the order, or method of operation when using the jig, should be marked on the drawing for reference. In some workshops the number of jigs used accumulates very rapidly, and it is a difficult matter for a stranger to know how many and exactly what type of appliances are already in existence for the various jobs dealt with in the shops unless a suitable system is employed for recording the jigs as they are made. It is necessary, therefore, to classify the work as far as possible. In addition to the ordinary drawing office records for turning up any particular number of drawing, an excellent plan is to have separate records of all the jigs required for each important piece of work, obsolete jigs being struck out and new jigs entered when they are made. A system of this kind is invaluable for reference, and shows at a glance to a new designer or foreman exactly what jigs have been constructed up to date for any particular job.

With the object of reducing the cost, and furthering the progress of jigs in the tool room, it is usual to standardise those details and devices that crop up frequently during the course of jig design.

These parts are usually made in quantities and kept in the stores for use when required. Such parts include guide bushes, wing nuts, clamping screws, knurled nuts and screws, &c., and are drawn out and tabulated on standard data sheets, copies ot which are handed to each draughtsman for reference in design.

Figs. 2, 3, 4, 5, 6, and 7 give the writer's practice with reference to the most common of these standard parts.

All unnecessary expense in pattern making should be avoided as far as possible, since it frequently happens that only one casting is required.

After completion each jig should be clearly marked with the name of the piece and the machine to which it belongs as well as the order number of that particular jig. If these precautions are taken the job may be readily recognised, and drawings may be found should repairs or renewal of parts be necessary; whilst the sizes of drills, reamers, and taps, as the case may be, should be stamped on the jig close to their respective bushings.

THE DESIGN OF CONTINUOUS-CURRENT TURBO-DYNAMOS.

(Continued.)

Inter-pole Machines versus Fully-Compensated Machines.

The Field Magnets.

HAVING fixed the dimensions of the armature according to the values of AC and e_s as shown in the first part of this paper, we have now to turn our attention to the design of the field magnet system. The ordinary and simple system of poles is unsuitable for turbine design, and in order to obtain sparkless commutation we are obliged to provide some method of compensation against armature reaction. The method adopted consists in supplying a reversing field or flux at the points where commutation takes place. In practice three distinct arrangements are followed :—

1. Machines with ordinary inter- or reverse-poles in addition to the main field poles.

2. Machines with main poles and interpoles, but with a compensating winding carried on the main poles—these are what the author entitles fully-compensated machines.

3. Machines arranged as No. 2, but without inter-poles. In reality this arrangement has inter- or reverse-poles, but these have air-cores. Such machines have been successfully constructed by Messrs. Parsons. It is to be noted, though, that this design seems to require from three to five times as many ampere turns for the compensating winding as there are armature ampere turns.

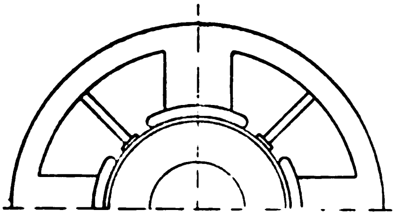


FIG. 4. INTER-POLE MACHINE.

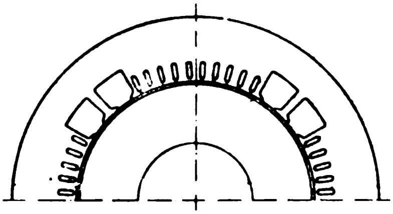


FIG. 5. FULLY-COMPENSATED MACHINE

There are therefore in reality only two arrangements to discuss, and opinions are still very much divided as to their respective merits.

For small or slow-running machines where there are no special commutation difficulties the first arrangement is quite sufficient. But this is not the case with high-speed dynamos, because it is not possible to obtain such satisfactory commutation from no load to full load and from full load to short circuit as can be done with fully-compensated machines. With the inter-pole machine, as with the ordinary simple pole dynamo, the matter is compromised by finding the most favourable brush position for commutation between no load and full load. This will be referred to later on. A point in favour of the fully-compensated arrangement is this: owing to the small number of armature conductors in a turbo-dynamo it is important that the flux emanating from all field poles should be

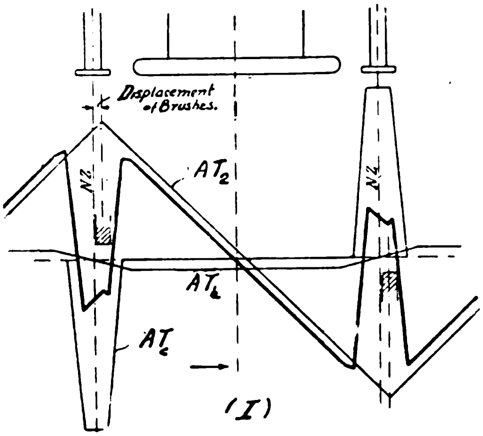


FIG. 6. CALCULATED M.M.F.S ON SHORT CIRCUIT FOR INTER-POLE MACHINE.

equal. Absolute equality is, however, only to be attained by building up the field magnet of stampings of uniformly soft iron, as would be the case in the fully-compensated machine (see Fig. 5), as compared with the doubtful uniformity of the iron in the field castings shown in Fig. 4, to which must be added unequal reluctances at the joints, &c.

The more completely the armature reaction is neutralised by a compensating winding on the field poles distributed over the whole circumference of the armature the greater is the security obtained for sparkless commutation at all loads. The uniform distribution of the compensating winding will prevent any distortion of the main field flux from no load to full load, provided always that the ampere turns of this winding are kept equal to the armature ampere turns. In the ordinary inter-pole arrangement such distortion is not avoided, and it causes unequal voltages between segments and also increases the iron losses by altering the flux density in different parts of the armature core. These losses are increased when the changes of load are sudden. Fully-compensated machines are, therefore, capable of a higher output by just as much as these losses, which can be avoided, amount to.

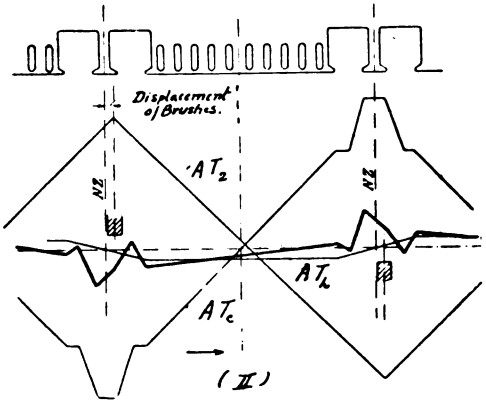


FIG. 7. CALCULATED M.M.F.S ON SHORT CIRCUIT FOR FULLY-COMPENSATED MACHINE.

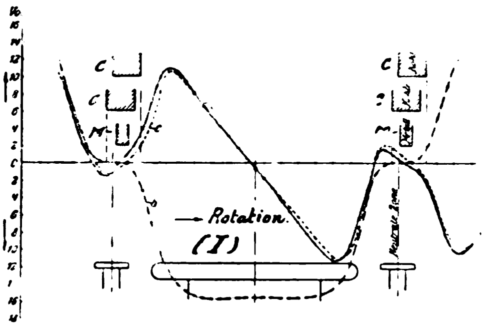


FIG. 8. ACTUAL FLUX-DISTRIBUTION INTER-POLE MACHINE. M, METAL BRUSH; C, CARBON BRUSH.

The exact conditions necessary to procure the correct neutralising field for sparkless

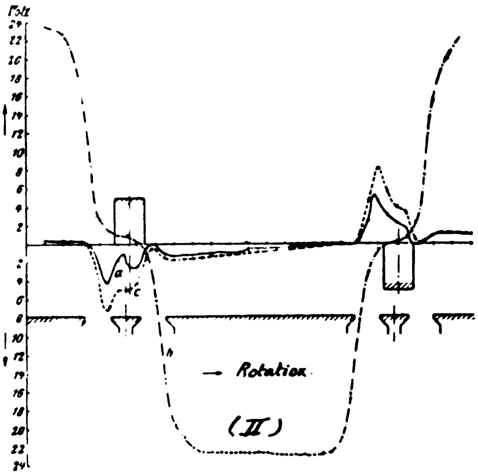


FIG. 9. ACTUAL FLUX-DISTRIBUTION FULLY-COMPENSATED MACHINE.

commutation at all loads cannot be stated in so many words. Experience and careful examination of the performances of modern machines can alone form a guide to the best methods. With a view to further elucidating the question the author exhibits field curves of two machines under various conditions, one an inter-pole machine (I.) and one fully compensated (II.). Both are turbo-dynamos, and the diagrams show in a marked degree the effects due to the different designs.

The tests were made on short circuit with full-load current, and on open circuit, the underlying idea being that the armature reaction would be greatest on the compensating or reverse pole winding during short circuit, and that therefore the effect would be a guide to the determination of the state of affairs at different loads, while on the other hand on open circuit the armature reaction is a minimum. The degrees of reaction must therefore lie between the two recorded positions of maximum and minimum. In the same way during short circuit the effective field is a minimum because it has only to force the current through the ohmic resistance of the armature. In Figs. 6 and 7 the fine lines show graphically the effective calculated m.m.f.'s under short circuit. AT_2 is the flux due to the armature ampere turns, AT_c to the compensating ampere turns, AT_h to the main field ampere turns. The thick lines show the resultant calculated flux at the circumference of the armature. As the iron of the armature will not be saturated under short circuit with normal full-load current, this thick line will approximately indicate the actual distribution of the flux. The actual field magnets are shown to the same scale in Figs. 6 and 7, and a slight advance of the brushes is indicated, the reason for which will be given later on. The compensating turns AT_c in Fig. 7 are 3 per cent. higher (per cm. of circumference) than the ampere turns at the armature AT_2. The particulars of the two machines are set out in Table I.

TABLE I.

I.—INTER-POLE MACHINE.	II.—FULLY-COMPENSATED MACHINE.
200kw., 4 pole, 3000r.p.m.	500kw., 6 pole, 1500r.p.m.
230 volts, 870amp.	230 volts, 2100amp.
$AC = 97.5$	$AC = 107.5$
$e_s = 19.5$	$e_s = 22.0$
$b/f = 0.71$	$b/f = 0.72$
$v = 73.5$	$v = 70.5$
$l_n = 24.4$	$l_n = 27.9$
No. of commutator bars = 66	No. of commutator bars = 87
Air gap (all poles) = 0.8c.m.	Air gap (all poles) = 0.75c.m.
Width of inter-pole = 4.5 ,,	Width of inter-pole = 4.5 ,,
Length ,, = 20.0 ,,	Length ,, = 27.9 ,,

The ampere turns of the compensating winding at full load were designed for

I.—1.67 × the armature ampere turns. | II.—1.12 × the armature ampere turns.

Figs. 8 and 9 show the actual flux distribution in the two machines. The curves marked *a* show the state of affairs on short circuit with full-load current; these correspond to the graphical thick line in Figs. 6 and 7. Curves *b* show the flux at no load with the normal exciting current. The revolutions were at all times kept to

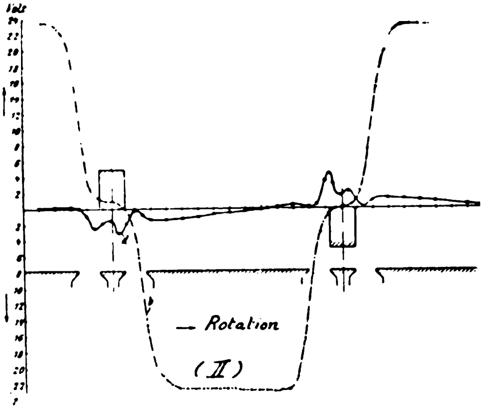


FIG. 10. SHORT-CIRCUIT AND OPEN-CIRCUIT CURVES, WITH BRUSHES IN NEUTRAL ZONE. FULLY-COMPENSATED MACHINE.

the normal as given in above particulars. In the short-circuit tests the brushes were placed in the most favourable position for sparkless commutation, and the compensating turns were likewise adjusted to obtain the best results. The ordinates represent the voltage between segments; the horizontal axis is divided to represent the polar arc reduced in terms of the diameter of the commutator. The horizontal divisions therefore represent the bars of the commutator.

The fully-compensated machine (II.) ran practically sparklessly with an over compensation = 1.08 × the armature ampere turns; sparking took place both with greater and with less compensation.

Curve *c* (Fig. 9) was taken with $AT_c = 1.24\ AT_2$, and slight sparking was noticeable at the trailing edge of the brushes. The compensating ampere turns were altered by shunting a portion of the current. It should be noted that the main poles remained unaltered with 1.03 × armature ampere turns.

Finally, the effect of altering the position of the brushes was investigated. For this purpose the tests (short-circuit) were repeated on No. II. machine with the brushes in the following positions:—

1. Brushes in the (geometrical) neutral zone = N.Z. (see Fig. 10).
2. Brushes advanced 0.2 × width of one segment (see Fig. 9).
3. Brushes advanced 0.4 × width of one segment (see Fig. 11).

In case 2 (Fig. 9, curve *a*) commutation was sparkless, as already stated. In case 1 (see curve *d*, Fig. 10) the conditions were otherwise the same as shown by curve *a*, Fig. 9; but brushes were set on N.Z. and sparking took place; this could only be reduced but not stopped entirely by increasing the $AT_c = 1.24\ AT_2$. Case 3. (Fig. 11, curve *c*) shows the brushes advanced 0.4 and the AT_c were $= 1.24\ AT_2$.

The interpole machine (I.) did not run as sparklessly under any conditions on the short-circuit test. Increasing or decreasing the ampere turns on the interpoles as well as moving the brushes made no improvement. Not even by using pure carbon brushes could sparkless running be achieved. In Fig. 8, curve *c* was taken with the $AT_c = 1.75\ AT_2$; but the brushes sparked just as much as on curve *a* (Fig. 8); the best position of the brushes is shown in the same figure. On the other hand, at full load this machine (with $AT_c = 1.67\ AT_2$) ran practically without a spark. But while with the fully compensated machine (II.) no increase of

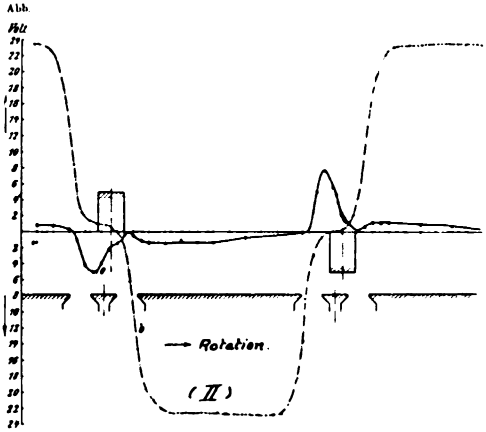


FIG. 11. SHORT-CIRCUIT AND OPEN-CIRCUIT CURVES, WITH BRUSHES ADVANCED 0.4 OF A SEGMENT. FULLY-COMPENSATED MACHINE.

sparking was noted between full load and short circuit, with the inter-pole machine an increase of compensating ampere turns was necessary, and even with 75 per cent. over-compensation sparkless running was not obtainable.

Fig. 12 gives curves *g* at half load, *f* at full load, and *b* again at no load for the inter-pole machine. Unfortunately the author was unable to obtain corresponding curves for the fully compensated machine.

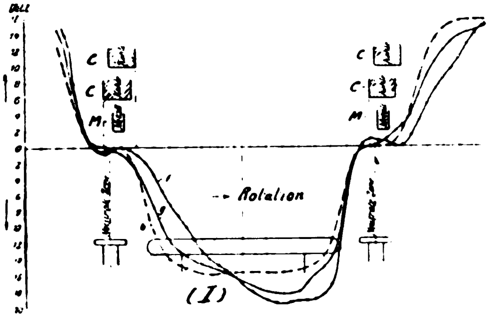


FIG. 12. CURVES AT DIFFERENT LOADS. INTER-POLE MACHINE

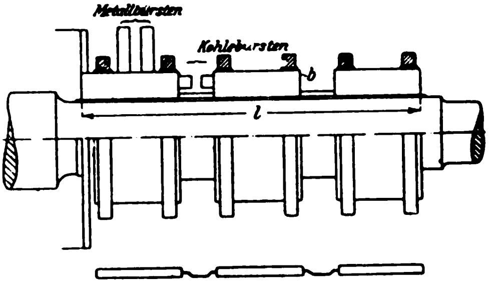


FIG. 13.

All the curves given point distinctly to a distortion of the field in the inter-pole machine, but more especially in the short-circuit curves. In the fully compensated machine there is no evidence of the negative flux which is so clearly shown in curves *a* and *c*, Fig. 8. This distortion is due to the cross-magnetisation from the armature, which not only distorts the main, but also the inter-pole fields. All this goes to show that the inter-pole machine is less suitable than the fully compensated one, owing to the difficulties of commutation which arise in high-speed machinery. In the fully compensated machine the cross-magnetising effect is entirely neutralised; there is therefore no distortion of the reversing field or of the main field, and hence no movement of the actual neutral axis. The brushes need never be moved under such circumstances, and as the reversing field is proportional to the strength of the main current there is always just the right counter M.M.F. to effect sparkless commutation. The experiments further demonstrate that it is the trailing edge of the brush which should be in the absolutely neutral position; they also tend to show that there is no object in shaping the shoes of the interpoles, except in so far as the greater the air-gap between them and the armature the less the distortion will be.

The Armature.—One of the essentials in armature construction from the point of view of sparkless commutation is freedom from vibration and general smoothness of running. If this condition is not fulfilled all the care taken to build up a correct field system will be wasted. The great difficulty is to obtain an insulating material which possesses sufficient mechanical strength to prevent movement of the conductors. For securing the end connections of drum armatures the author prefers a complete brass end-plate as offering the greatest security.

Armature Winding.—Symmetry is important. The winding pitch should differ from the pole pitch as little as possible.

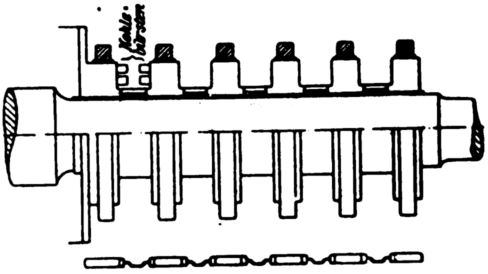


FIG. 14.

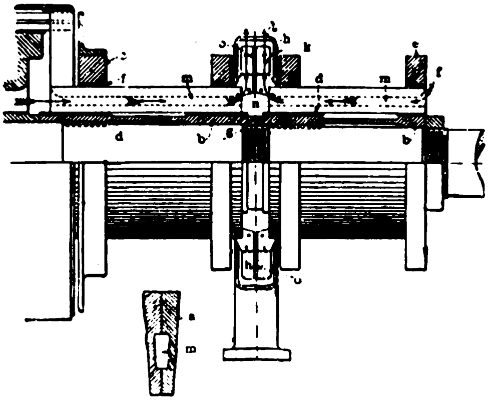


Fig. 15.

The number of slots should be equal to the number of bars if possible. In any case it is of the greatest importance that commutation of brush sets of the same polarity should synchronise accurately. Good results have been obtained by arranging the winding so that commutation of the positive brushes is displaced by half a period of commutation from that of the negative brushes. Potential equalising connections should be unnecessary in a good symmetrical winding, while they are positively harmful if there is any inequality in the field flux; the resulting cross currents are quite beyond control or measurement, and may cause serious distortion of the field. In an inter-pole machine this may be serious. On the other hand, without these inter-connections the current in each bar can be measured and steps can be taken to equalise these if necessary, thus balancing the armature electrically as well as mechanically.

Commutator.—The difficulties of commutator construction are well known. Mechanically it is the most delicate part of the machine. Among the important desiderata are:—

1. The use of the thinnest possible layers of insulation.
2. Large surfaces for compressing the insulating material and low specific pressure.
3. Avoidance of expansion, or, in other words, efficient cooling.
4. Low peripheral speed.
5. High compression of the parts.

The most serious effects are due to longitudinal expansion of the segments, and this can only be met by (*a*) preventing any considerable temperature, (*b*) by subdividing the segments in the axial direction into a number of short parts which may be inter-connected by flexible conductors similar to expansion joints in a steam pipe. Fig. 13 shows a proposed arrangement in which metal brushes are used as well as carbon brushes. Fig. 14 is a similar arrangement for carbon brushes only. Fig. 13 forms a combined disc and ordinary peripheral commutator, while Fig. 14 is entirely a disc commutator which is sub-divided to such an extent that the effect of temperature rise may almost be neglected.

Brushes and Brush-holders.—These parts are of great consequence in the matter of

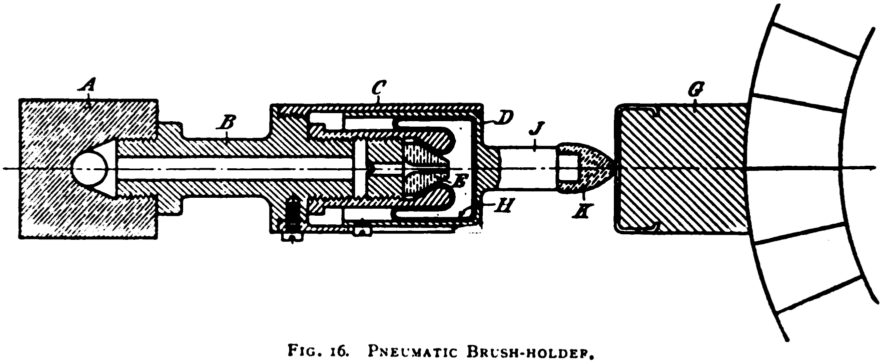


Fig. 16. Pneumatic Brush-holder.

sparkless commutation. Suitable spring damping devices should be provided to minimise the effect of mechanical vibration; the brushes should therefore be very light, while the holders should be of very solid construction.

Carbon brushes are most suitable for disc commutators, while metal brushes work well on ordinary peripheral commutators, the reason being that the carbon brush cannot stand the inequalities due to the unequal wear of the mica and the copper, whereas metal brushes cut the mica at the same rate as they do the copper and so give no trouble. In every case the friction of pure carbon brushes is so much higher than that of metal brushes that special cooling arrangements become necessary, and hence the efficiency of the machine is somewhat lowered. This percentage loss may be appreciable (1 per cent. to 2 per cent.) in low voltage machines turning out heavy currents. Carbon brushes are, therefore, more suitable for high pressure machines.

The arrangements for ventilating the commutator are numerous. One of the best would seem to be that designed by Messrs. Siemens Bros. & Co. (Fig. 15), in which the commutator bars have passages formed longitudinally through which air is drawn. Fig. 16 shows a pneumatic carbon brush-holder; this should be an ideal arrangement if it were not for the consideration that a failure of the air supply would inevitably ruin the machine. Fig. 17 illustrates an arrangement devised by the author which has given good results. The carbon brush *a* is held in a brass extension piece *b*, holding a solid rubber pad *c* in place. The top of *b* is slotted so as to allow the spring *e* to press directly on the rubber through the leather *d*. Side springs *f* are also provided, so that chattering is impossible.

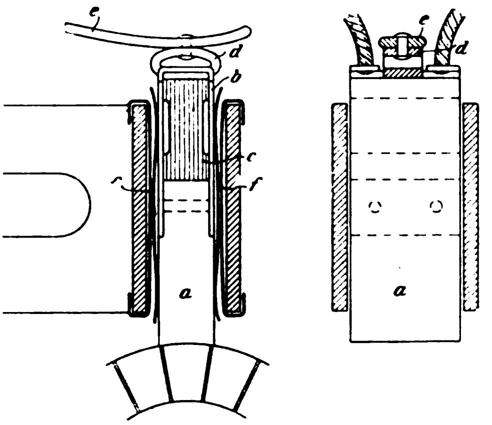


Fig. 17.

The greater the sub-division of the brushes the better, as small brushes meet the possible unevennesses better and have less inertia; to these may be added the further advantage of increased cooling surface.

Noise Produced by the Machines.—This cannot be entirely avoided, but certain points are to be noted. The teeth of the cores should be under-saturated, core stampings very firmly tied together, and sharp corners and edges avoided in the air cutting parts of the machine. Greater solidity of the core plates is desirable, and is obtained by condemning radial ventilation and only using axial ventilation ducts, thus doing away with the more or less weak distance pieces. The most effective stop to noise is to totally enclose the machine and resort to artificial ventilation at the expense of efficiency.

Excitation.—For turbo-dynamos running in parallel a separate exciter for each machine is provided driven off the turbine shaft; this gives greater reliability, and a low voltage exciting current can be economically used. Of course the machines when running in parallel will have a similar characteristic to that of an ordinary self-excited machine when running by itself.

MODERN VALVES.

[*Continued.*]

THE full-bore type of reducing valve is one which is largely used, not only by engineers for steam pressure reducing, but also in connection with water supply. This type of valve is constructed so that it will not wire-draw the reduced pressure steam, and, having a large lift, will supply any demand for reduced pressure steam up to the full internal diameter of the pipes. In the most improved forms the incoming steam enters on the top of the valve, so tending always to close it. No matter how high the valve may lift, the reduced pressure is kept constant, the modern practice being such that there is no spring arrangement connected to the movement to alter the reduced pressure, as is the case with valves which have their spring arrangement directly connected to the valve rod through crossheads. The low-pressure type of valve is constructed for supplying reduced pressures at low or atmospheric pressures, or if desired below atmospheric pressure, from any boiler pressure up to 200lb. per sq. in.

The mechanism of this type of valve is far from complicated, whilst its efficiency is extremely high. The greater the difference between the reduced and the initial pressures the more securely and tightly is the valve held in its seat. There is a large main valve entirely of metal, free from any complications in the shape of levers, toggles, or stuffing boxes, which is controlled by a pilot or regulating valve, also of the simplest possible construction. This latter is provided with an index indicating the range of reduced pressures that can be obtained, and by means of a simple additional device the valve can be provided with a lock-up arrangement at any desired pressure. The makers of this particular type of valve say that in cases where there is any great difference between the two pressures, i.e., the initial and the reduced, the best policy is to fit a reducing valve which has an inlet bore smaller than its outlet bore, and they instance that in reducing from 160lb. to, say, 80lb. per sq. inch where a 6in. low-pressure pipe is in use, a valve with a 4½in. or 5in. inlet will be quite sufficient for the purpose. Such a course, it will be seen, not only reduces the cost, inasmuch as a smaller valve can be used, but a more suitable size, in which there will be no wire-drawing, nor wear and tear on the seat or valve from this cause, can be fitted.

A certain confusion of thought frequently occurs in connection with reduced pressure and surplus steam valves, and the difference in action between the two types may be illustrated as follows. If there are two ranges of boilers in which the steam is at different pressures, one being at, for example, 160lb., whilst the other is at only 100lb. to the square inch; from the higher-pressure boilers steam is taken to supply engines at 155 or 160 lb., and this necessitates these boilers being always kept almost up to blow-off pressure, whilst there is a shortage of steam in the low-pressure boilers which necessitates their being fed from the high-pressure range; then a surplus steam valve should be provided under such conditions, as it will not draw down the high-pressure boiler pressure below that to which the valve is set and will only allow steam to pass through to the low-pressure boilers when there is a surplus of steam in the other range. But if, on the other hand, it is found that with the same boilers there is always a shortage of steam in the low-pressure range, which must be made good from the boilers working at the higher pressure, then a pressure-reducing valve should be fitted. A surplus steam valve is controlled by the high-pressure steam only, and is absolutely unaffected by the reduced pressure. A reducing valve, on the contrary, is controlled entirely by the reduced, and works irrespective of the high, pressure. It is pointed out by the makers that it is of importance that an additional safety valve should be fitted where either a reducing or a surplus steam valve is put between boilers, as the low-pressure boiler safety valves are as a general thing only designed for dealing with the steam that is generated by the low-pressure boilers themselves and are not suited to deal with the supply which is fed to them from the higher-pressure boilers. In some instances it has been found at certain hours that little or no steam is being used from low-pressure boilers which are coupled to a high-pressure range by means of a surplus valve, and accordingly these boilers would blow off at their safety valve pressure. If, coincident with this, surplus steam comes through from the higher-pressure boilers, then, if no additional safety valve has been fitted, the existing low-pressure safety valve may be severely taxed.

Bearing in mind the difference in operation between the surplus steam and the reducing valve, it will be seen that one of the best methods of surmounting the difficulty mentioned would be by fitting one of each type of valve in series, the surplus valve first and the reducing valve fitted to its outlet. This course is recommended by Messrs. Auld, who make a speciality of these valves. They say that with such an arrangement there is no danger of straining the boilers as in the instance mentioned. With both boilers under blowing-off pressure the surplus valve might open and pass steam, but it could not get through the reducing valve, as the latter would be held to its seat by the low-pressure steam. This is now the almost invariable practice where there are a number of coupled boilers operating at various pressures and with varying demands, although it is more costly than using only the surplus steam valve. A combined surplus steam and reducing valve has recently been devised, and is much cheaper than using the two types in series.

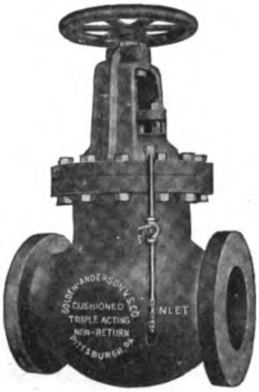


FIG. 1. TRIPLE-ACTING CUSHIONED NON-RETURN VALVE.

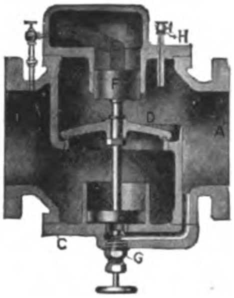


FIG. 2. SECTION OF HOCHFELDT "ECLIPSE" BACK-PRESSURE AND RELIEF VALVE.

It will be found in practice that a reducing valve will give the best results when it is fitted at some distance from the point where the supply of steam is to be given. Especially is this the case where an engine is being supplied with steam through a reducing valve and there is only a very short line of pipe between engine and valve. In such a case a reservoir should be provided which should consist of a steam receptacle of two or three times the capacity of the engine cylinder and built to withstand, with

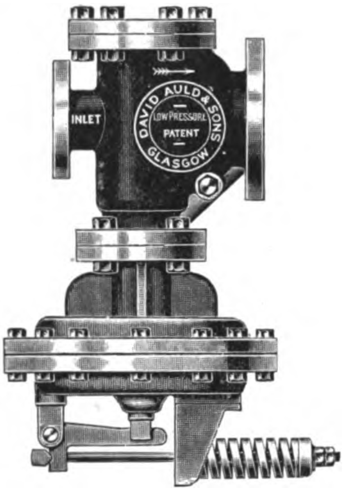


FIG. 3. LOW-PRESSURE AND VACUUM-REDUCING VALVE.

ample margin, the pressure of the steam. Unless some such precaution as this is taken the reducing valve will be liable to open and close with every stroke of the engine, thus being subjected to an abnormal amount of wear and tear. It must be remembered that the steam in passing from a high to a low pressure through a reducing valve is merely expanded, yet at the same time it retains some of the heat of the initial pressure. For this reason even if the steam is carried for some distance there is not the amount of condensation that there would be had low-pressure steam been taken direct from a boiler. Thus, it is pointed out, in reducing from 160lb. to 80lb. per square inch the reduced pressure steam is superheated and dried about 20deg. Fahr. above the temperature due to pressure, and when reducing from 160lb. to 10lb. per square inch the low-pressure steam is superheated, over the normal heat of that pressure, about 100deg. Fahr. A low-pressure and vacuum reducing valve, Fig. 3, by courtesy of the makers, is illustrated herewith; a considerable number of these are at work in connection with low-pressure and exhaust steam heating apparatus and exhaust steam turbines. When working in connection with steam turbines and exhaust steam they are set between the live steam main and the exhaust main. Should the pressure in the exhaust main fail from any cause, such as stoppage of the engines or other reason, then the valve comes into action and supplies steam automatically at the correct pressure from the live mains to make up the deficiency, the valve automatically going out of action as soon as the exhaust steam pipe is in a position to feed the turbines.

The action of a surplus steam valve may be described as follows: High-pressure steam enters the main valve chest by the inlet pipe, and by being above the main valve keeps this tightly closed. The smaller regulating valve is spring-controlled, Figs. 4 and 5, and is held shut until the pressure acting upon it exceeds that to which the valve is set, when it will open and allow high-pressure steam to pass along into a cylinder, where it acts on the underside of a piston. This piston is of greater area than the main valve, against which the same pressure is acting, and surplus steam is thus allowed to pass to the outlet side of the valve. As soon as the pressure of the high-pressure steam falls below that for which the valve has been set, the regulating valve is closed by the action of the spring and the passage of steam into the cylinder is thus stopped. The main valve is thus allowed to come to its seat and the supply of surplus steam is shut off.

Whilst surplus steam and reducing valves of the type described may be implicitly relied upon effectively to control the supply of steam, it has yet been felt that there was a demand for a valve which would operate instantly and automatically in the event of any such accident as the bursting of a pipe or fitting. Such a valve, on the cushioned, triple-acting, non-return principle, is already on the market. This is quite automatic in action, and, in the picturesque language of an American enthusiast, it even eliminates dependence on the presence of mind of employees to remember the location of three-way cocks or valves to turn steam on to operate the emergency valves in case of accident. The non-return feature automatically protects the boilers in such events as the bursting of a tube, and will act as a safety stop to prevent the distressing accidents which are, unhappily, too frequent when live steam is turned into a cold boiler in which men may be at work scaling or removing the nuts of the boiler fittings. There is an automatic safety stop fitted which protects life and property in case of a main steam pipe bursting, and it will cut off, positively, the supply of steam from the boilers until the break is repaired. In an emergency the device can also be used as a steam closing valve and can be operated from any desired part of the building independently of the pilot valves. It may also be closed by hand in the same way as an ordinary valve.

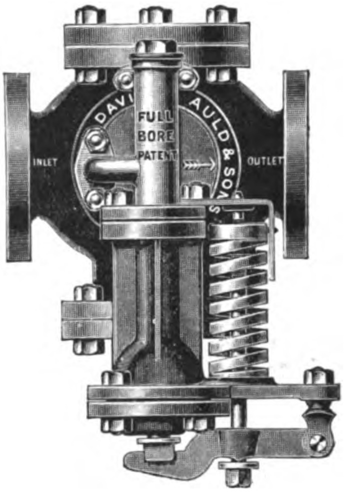


FIG. 5 REGULATING VALVE IN STANDARD POSITION.

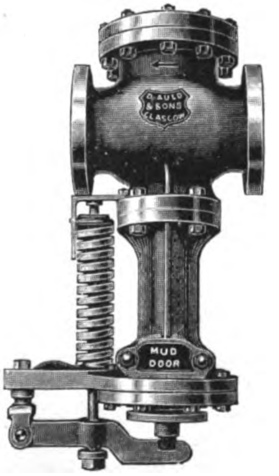


FIG. 4. REDUCING VALVE, SPRING-LOADED TYPE.

The cushioning of the valves in question is by means of a Corliss dash-pot, which occupies the full area of the upper portion of the body. This ensures a positive cushion in the opening and closing of the valve, together with perfect alignment of the seat at all times, regardless of the position. In construction the piston of the dash-pot is attached to the spindle. The cylinder of the dash-pot is of bronze, and is held firmly in place by means of a flange clamped between the body and the bonnet of the valve. A by-pass admits full boiler pressure above and underneath the inside dash-pot, which is thus perfectly balanced. A connection from the main steam pipe to an automatic pilot valve causes the latter to be kept closed on account of the greater area above its valve. There is also a steam connection between the dash-pots which leads to the pilot valve. If the live steam pipe is ruptured pressure is removed from the top of the pilot valve, which allows it instantly to open. This exhausts the pressure from between the two dash-pots. As the full boiler pressure is always above one of these the valve will close, and it is at the same time cushioned in its operation. The automatic pilot valve used in conjunction with this valve is positive in operation and simply constructed. The non-return valves (Fig. 1), say the makers, the Golden-Anderson Valve Speciality Company, of Pittsburg, can be tested at any time and as often as desired without interfering in any way with the working of the plant. It may be mentioned that the valve is perfectly balanced, and all springs are eliminated. The valves are of the heavy type, and owing to the care with which the mechanism has

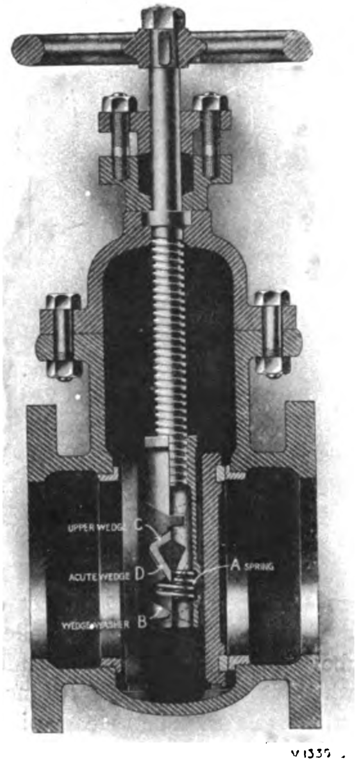


FIG. 6. DIAGRAMMATIC SECTION OF FULL-WAY VALVE.

been designed and the parts finished they neither chatter, hammer, nor stick.

Another American valve which is built for hard continuous service is known as the "clean seat" valve, and a feature in connection with this is that the seat and disc are self-cleaning, and yet the parts are of so substantial a character and so accurately fitted and adjusted that no injury is done to the seating by the self-cleaning device.

In construction the bottom of the disc is hollow, with solid cast eccentric lugs on the side. The slot or groove is cut through the lugs and also through the entire outside diameter, consequently when the slot or groove comes flush with the seat the steam, air, or water dealt with is caused to pass in jets directly across the disc and its seating, absolutely freeing them from sediment or deposited scale. It is said that under conditions when the pressure is admitted on top of the disc the self-cleaning device operates in quite as effective a manner, and has a decided advantage over other makes when the valve is not completely closed.

The ruinous effects of the wire-drawing of the steam are provided against by the addition of a projection on the bottom of the valve or disc. This is so arranged as to act as the first cut-off or throttle in protecting the seat. This special feature is especially important when the valve is slightly open; the projection is large and substantial, and as the bottom of the disc is hollow, the steam or water will pass in the shape of a jet through the slot or groove without injuring either the disc or seat. This valve can be packed when open by a similar arrangement to that mentioned in connection with the regrinding valves. The back of the valve disc is faced, and when the valve is opened to its fullest extent this comes into close contact with the faced bottom of the bonnet. The bonnet is constructed with a long thread engaging the body of the valve with a bevelled joint, thus ensuring that an absolutely tight joint can be made. This fact, coupled with the substantial and heavy construction of the valve, gives great resistance to the various stresses which are brought upon this particular part.

Another form of this valve, specially devised for use as a blow-off valve, is constructed with a renewable seat and disc with a Babbitt or other flexible metal insertion that can be quickly refilled if found necessary. The disc is made to slip on or off the spindle when removed from the body.

An interesting form of non-return valve has recently been patented by Alexander Rotherham, and Templer and Raneo, Ltd., of Coventry. The invention relates to combined isolating and hand-stop valves of the type in which a dash-pot or other cushioning device is used in order to effect a silent closing of the valve and to prevent chattering. The dash-pot in the new type is situated not inside, but on the exterior of the casing of the valve, and it is so arranged as to be operated in conjunction with the valve through a suitable connection which passes from the interior of the valve casing. A study of the drawing submitted with the patent, which cannot, unfortunately, be reproduced, shows that the under side of the valve disc is fitted to a sliding rod which is led through a packed, steam-tight joint in the lower portion of the valve casing into the dash-pot or buffer device. The sliding rod is screwed into a piston working in this dash-pot, which is filled in the usual manner with oil or other suitable liquid. The piston is a fairly tight fit, but holes are drilled through it so that the oil can pass from one side of the piston to the other. The size and number of the holes will obviously regulate to a considerable extent the speed at which the piston can move. A spring is attached to the sliding rod which tends to hold the disc of the valve firmly on its seat, and amongst minor details of construction it is suggested that the rod shall preferably pass through the end cover of the dashpot cylinder.

The Hochfeldt combination relief and back-pressure valve, which is illustrated by the courtesy of the Hughson Steam Speciality Company, who have taken over its manufacture (Fig. 2), is designed to meet the demand for a reliable relief and back-pressure valve combined in one casing, and which shall at the same time meet the requirements of the various vacuum heating systems.

The Hochfeldt valve appears to answer all these requirements admirably. By opening or closing a small by-pass the change from relief to back-pressure service can be made instantly. The body is of cast-iron, whilst all working parts are of bronze, including the valve seat. The clapper has a seat of Babbitt metal, whilst the levers and shafts are forged iron with an ample allowance of strength.

The valve is noiseless in operation, and is made in both vertical and horizontal patterns. A reference to the illustration shows that the by-pass admits steam on the top of the piston F, the steam thus pressing the clapper D against the seat. This does away with springs or weights on the lever, and

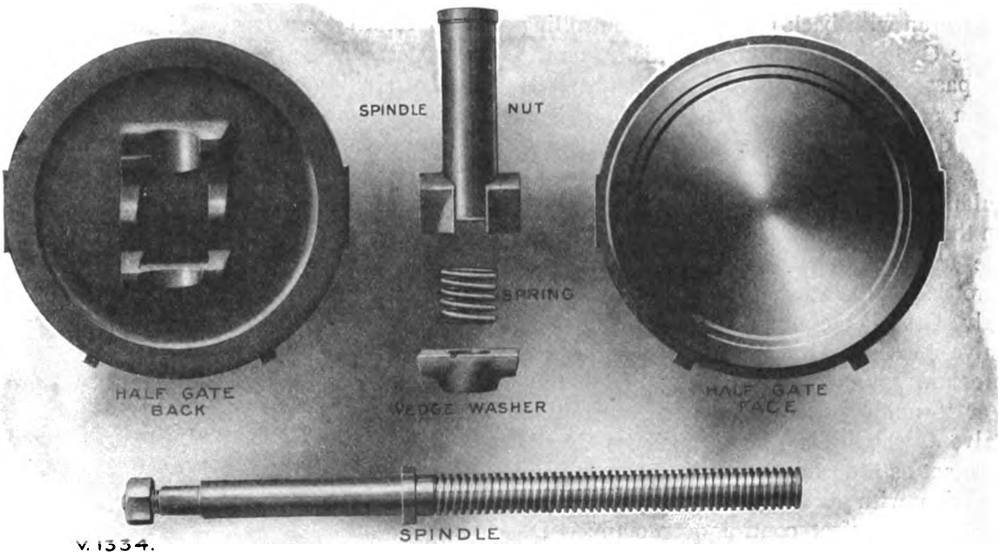


Fig. 7. Working Parts of Full-way Valve.

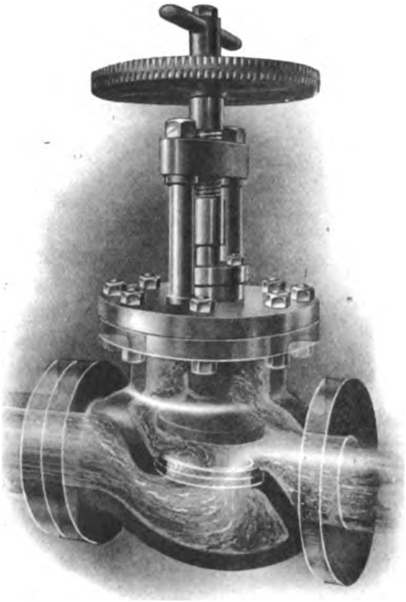


Fig. 8. Valve of Incorrect Type showing Eddying of Steam.

incidentally it may be mentioned that the piston F is fitted accurately and provided with brass packing rings. The following description of the working of the valve may be of interest, and is easy to follow by means of the illustration:

To run with back pressure the controlling valve G should be opened. This opens the by-pass, and as clapper D and piston E form a semi-balanced valve, piston F acts as a dash-pot to prevent any violent action. The back pressure wanted is to be counterbalanced by placing the necessary weights on the long end of the outside lever. Should the valve chatter, the by-pass should be throttled a little by closing the controlling valve G until the valve works quietly. The valve is so sensitive that it will control the pressure to a small fraction of a pound. For "running condensing" the controlling valve G should be closed. Piston E will now act as a dash-pot in cylinder E in conjunction with dash-pot F, thus forming a means of perfect control over clapper D. For water seat, running water should be connected to valve K, which should be opened until a slight drip at L shows that there is sufficient water for the purpose. The lever is now used to open and close the valve only. In case the vacuum breaks, the valve will open immediately, thus relieving the engine, and will stay open without chattering on its seat. The valve can be made to open more quickly if required by hanging weights to the short arm of the lever in order to balance the weight of the various moving parts.

Low-pressure regulating valves are also made for service in connection with heating systems, and are usually made with an enlarged outlet to allow of the quick expansion of the steam. An improved form of vacuum-pressure regulating valve is constructed with an independent diaphragm which is actuated by pressure taken from the low-pressure side at a distance from the valve at a point of regulation which can be decided upon when planning out the system. This type of valve is most accurately balanced, and will respond to the slightest variation in pressure. It is two seated, and so constructed that the seats will adjust themselves to any changes of temperature, with the result that the valve is always tight in use.

To return to valves used in connection with steam above atmospheric pressure, it has been ably stated that the commonly received opinion that the drop in steam pressure between boiler and engine or other

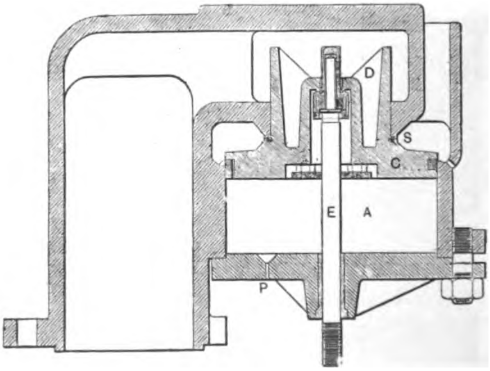


Fig. 9. Section of "Servo" Regulator.

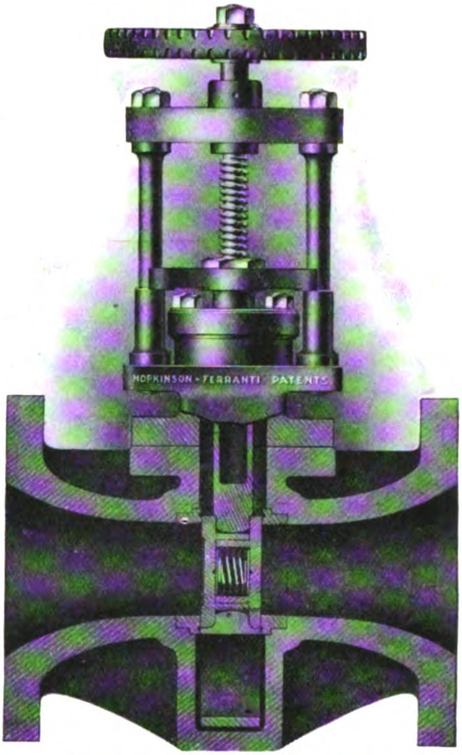


FIG. 10. HOPKINSON-FERRANTI VALVE.

steam-consuming device, which may amount to as much as 5lb. or 10lb. per square inch, is a matter of little moment, is erroneous. It is not a fact that the superheating of the steam by friction in the pipe, reducing the initial condensation in the engine, replaces the loss in pressure. It is pointed out that the steam expands adiabatically, not isothermally, when overcoming the friction of the pipes, and it has been demonstrated by repeated experiment that it really does fall to the temperature natural to any saturated steam at the lower pressure, and the steam is passed into the cylinder of the engine or other steam-containing vessel charged with a certain quantity of moisture or water. The bulk of this friction, which thus results directly in a loss of efficiency, occurs at the stop valve, for which reason Messrs. Alley and Maclellan, Ltd., have introduced their "Straight-way" valves, which are specially designed to prevent this friction at the stop valve as far as possible. They point out that there is further waste of steam should water be deposited on any irregular portion of the steam piping. Where this happens, as in badly-designed valves, owing to wet metallic surfaces absorbing heat much more readily than similar dry surfaces, a large amount of heat is taken from the steam and rapidly passed out of the system and lost. For this again they claim their valve is an effective remedy.

One of the best known of these types is the parallel slide pattern, in which there are two gates in each valve, both of which are pressed on the seatings, and are, of course, absolutely steam-tight. As these gates are positively traversed there is no possibility of their jamming; they are always kept on their faces, and are entirely self-cleaning in action, without any risk of cutting through the seats by wire-drawing of the steam. The movement is simple and easy owing to the perfect balance, and the valve can be used to admit very small amounts of steam, as for warming the pipes. The valve faces, which, with the spindle and spindle brushes, are of best bronze, are machine finished. The screw is not exposed to the action of the steam, and forms a valuable index showing the amount to which the valve is open. The chest, cover, gland, bridge gates, and hand-wheel are of Scotch iron for the ordinary valves, but for positions where there is possibility of excessive super-heat, these parts are made of mild cast steel. Valves of this type are suitable for pressures of 200lb. steam.

The wedge-gate valves are constructed on similar lines to other valves of the same type, with the exception that they open to the full diameter of the pipe line. The chest, cover, gate, and hand-wheel are of grey iron, and the four faces, spindle, and spindle nut of bronze. These valves are only recommended for 100lb. steam pressure or for exhaust piping. They are, as is usual with the type, tested to 200lb. hydraulic and 100lb. steam pressure.

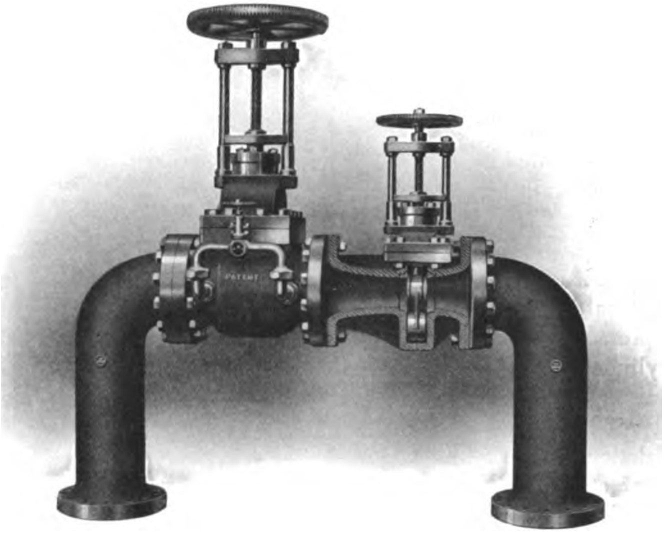


Fig. 11. Comparison between Simple Valve and Hopkinson-Ferranti Valve for Similar Service.

Where valves for use with light pressures are fixed in positions where they may require to be opened quickly or frequently, they can be fitted with levers, but such valves should not be used under heavy pressures or on a light or long pipe-line. The sudden cut-off of the flow naturally throws a strain on the valve and the pipe-line proportional to the pressure of steam, and if an attempt were made to cut off instantaneously a heavy pressure on a light line of piping by means of a lightly-constructed valve the results would probably be disastrous. These valves may be correctly described as time-savers. Another type of valve which also merits the name is the quick-acting wedge-gate. In this, when the spindle is turned, it traverses in the nut which is held between the main and the top covers, thus moving the gate or plug, which also traverses along the spindle. This design of valve is largely used in chemical and filter plants, where the valves are operated many times a day.

The "Sentinel" full-way valves made by the same firm are of recent introduction, but there is no doubt that they have already justified their position. The valve has a clear straight-way equal to the diameter of the piping, and, like the other types described, opens easily, and may be used for warming up the pipe-line. The easy action prevents any sudden rush of steam, as with the ordinary screw-down valve, and so the risk of damage by water-hammer is, if not entirely eliminated, at least greatly reduced. The gates are always kept on their faces, and, like the previously mentioned patterns, are self-cleaning in their action. They are noiseless, and as the closing wedge does not come into action until the spring is compressed, the valve may be placed in any position. A further point in which this valve is superior to many others is that the gates are never traversed, even for the thousandth part of an inch, with the full closing pressure on them. In construction the valve is simple yet solid, and by the courtesy of the makers an illustration of the working parts is given (Fig. 7). The seating rings in the valve chest are screwed in, and are easily renewable in case of wear; the gates, together with all the other working parts, are standardised, interchangeable, and easily replaced if required. The screw and nut have machine-cut threads, and the well-rounded shape and stiffened corners make the chest as strong as possible for its size.

The action is described as follows:—The half-gates are free to move apart slightly. They are thus able to come firmly against the chest rings, but there are certain interlocking projections which compel them to slide together when the valve is being opened or closed.

A reference to the section (Fig. 6)

of the valve shows that when the valve is not tightly shut the spring **A**, acting between **B**, which is the wedge washer, and **C**, which is the upper wedge on the spindle nut, presses the half-gates apart and on to their seats.

In closing the valve the half-gates are, by the action of the spring **A**, kept ahead of the spindle nut which is traversed by the spindle, but it will be seen that as soon as the valve is completely closed the gates are unable to travel further by reason of the projection on their lower parts meeting the valve chest. Further movement of the hand-wheel brings the spring **A** into compression, and the acute-shaped wedge **D** is at once brought into action. Both half-gates are thus pressed powerfully on to their seats.

When the valve is being opened the first movement of the hand-wheel withdraws this wedge **D**, and a further movement slides the half-gates open. It has been shown, by the successful operation of many thousands of parallel slide valves, that the spring action is durable even when working under steam pressures of 250lb. superheated, and even were the spring from any cause to fail, the valve would still be as effective in use as the majority of other types of valves in a perfect condition.

Special attention has been paid by most valve makers to the question of water-hammer, as the majority of accidents to steam-piping are due to this cause. A German Government Commission was held to investigate this and other subjects, and it was ascertained that the pressures due to the sudden stoppage of a body of water driven by steam pressure along a pipe to the valve are almost always in excess of four times the boiler pressure. Sometimes, but only rarely, the increase amounts to thirty times the steam pressure in the boiler. Accidents due to this cause can generally be avoided by warming the pipe, before turning on the main valve, by means of a by-pass or similar device. A gradual-opening device is sometimes incorporated with the valve, and one particular form worthy of notice is that in which an internal valve works inside the cylindrical part of the seat and during the first opening turns of the hand-wheel no more steam is allowed to pass than would be admitted by an ordinary by-pass. Further opening of the valve gives an area equal to the internal diameter of the piping. Messrs. Alley and Maclellan claim a certainty of action in this connection for this valve which is most valuable. A single omission or instance of forgetfulness might cause serious damage, but with this valve such an accident would be impossible.

Water-hammer will, of course, be avoided if the pipes are kept free from water, but this can only be ensured if the valves are quite steam-tight. Even the best makes become leaky after considerable use, and so the firm have introduced renewable valves and seatings somewhat similar to those already described. The seat of the valve is held in place by bolts and nuts which, to prevent corrosion, are of bronze. These are renewable, and are so arranged as to allow of the expansion of the seat, and clearance for this purpose is also left in the valve body. It is recommended that when a leaky valve or seating is withdrawn and replaced by new parts, the worn parts should be ground up and kept ready for putting into service again as soon as the new parts become worn in turn. The operation of renewing parts is not a lengthy one, and it is said that a handy labourer can do all that is required, and that the renewal of a 10in. valve need not take more than ten minutes, and no tools other than a spanner are necessary.

As it is often necessary in electric lighting or power supply stations to meet a sudden increase of load, this can only be done by cutting in stand-by boilers which have been kept ready under steam. If the stop-valves which connect these boilers to the pipe-line are opened before the pressure of the reserve boiler is equal to that in the steam piping, steam will be suddenly drawn from the boilers already at work, pressure all round will be suddenly reduced, and the working boilers may prime excessively. On the other hand, if the stand-by boilers are at a higher pressure, as soon as the valve is opened they in their turn will have pressure suddenly reduced, and will also prime or foam, serious damage perhaps resulting. An arrangement in the shape of a check fitting has been added to boiler stop-valves in which the spindle is free from the valve, the top of which forms a dash-pot. When it is decided to put in the extra boilers the stop-valve spindles are raised at once, and when the pressure inside equals that in the steam-pipe the valve automatically opens, gently and gradually, at exactly the correct moment, cushioned by the dash-pot.

An interesting form of valve is that which is filled with an elastic copper renewable seating. It has been found that if the valve, particularly in the smaller sizes, be screwed down too violently the discs spring, and so wear quickly. The valve in question is fitted with a seating which consists of a copper sheath with a core of asbestos. Sufficient compressibility is obtained to ensure an absolutely tight shut-off, whilst the copper sheath not only resists wear and grinding effect, but also protects the core from the disintegrating effects of the steam. Another and somewhat similar form has, instead of the ordinary seating, a joint formed by a special seamless soft copper ring attached to the spindle, on a loose head, by an easily adjustable lock-nut. This ring, which acts on a very slightly coned brass seating, is the only wearing part, and it can be replaced in a very few moments. The slightly coned seating is claimed to be a most important feature, as it is impossible for any foreign matter to become permanently fixed thereon. These valves are not only made for ordinary steam pressures, but also for controlling superheated steam.

One of the newest appliances placed on the market by the makers of the foregoing valves is the "Servo" steam regulator, made by the Hulburd Engineering Company, who courteously afforded the writer an interview, and favoured him with a description of the regulator. A reference to the sectional drawing herewith (Fig. 9) will serve to make the explanation of the regulator and its action more clear.

The regulator has already been fitted to nearly one thousand locomotive engines, and ensures extremely sensitive and complete steam control throughout the entire range of movement. The valve is absolutely balanced and entirely steam controlled, thus requiring no more effort on the part of the attendant than is sufficient to overcome the friction of the moving parts. It consists of a single seated main valve C, formed with a cylindrical throttle valve extension D on its outlet side and a piston on its steam side, containing an auxiliary relief or balancing valve K, which terminates in a slender conical plug, and is attached to the valve spindle E. There is no direct connection between the valve spindle and the main valve.

The piston, which is rendered steam-tight by an ordinary piston ring, works in a cylindrical extension of the valve casing, forming with it a balancing chamber A. This balancing chamber is in permanent communication, by means of a small hole P in the valve casing cover, with the boiler, and is thus kept under steam pressure, which, so long as the auxiliary valve K is closed, presses the main valve firmly against its seat S.

The regulator is operated by drawing the balancing valve K from its seat within the main valve, thus allowing the steam from the chamber A to escape past its conical point until the rate of flow out of the chamber past the valve K is in excess of the steam supply to it through the orifice P, and the pressure in A is therefore reduced.

When the pressure in A is thus brought down to a certain point it is insufficient to keep the main valve closed against the steam pressure, which is constantly exerted in an opposite direction on the other or valve side of the piston. The piston is therefore forced inwards into its cylinder, and draws with it the main valve from its seat.

The main valve now takes up a definite position in relation to the auxiliary balancing valve, and so adjusts itself with regard to it that the overflow of steam from A past the small valve K exactly equals the supply admitted through the passage P, which is in permanent communication with the boiler. The main valve, in fact, under these conditions, is perfectly balanced, and may be said to be actually floating upon the steam. When it is in this position it responds instantly to the slightest movement of the auxiliary valve and spindle. No matter in what position the auxiliary valve may be at rest, the main valve is rigidly held by the steam in that position also. If the auxiliary valve is either withdrawn or advanced, the main valve automatically follows it as if the two were connected. The condition that inflow and outflow of steam in A are equal is automatically re-established whenever it is disturbed without the slightest indication of oscillation or hunting. Indeed, say the makers, so sensitive and absolute is the control afforded that, as has been demonstrated by experiment, a driver is able to raise his steam-chest pressure at will, and with the greatest certainty, by regular increments of 2lb. throughout the whole range of pressure.

It might be considered that the manipulation of such a valve would entail a considerable amount of labour, but such is not the case, the effort, on the contrary, being practically insignificant. The auxiliary valve, which is the only one which has to be raised by hand against steam pressure, does not exceed in any case 1in. in diameter, and the main valve is, as explained, moved by the steam itself, being set in operation and controlled by means of the auxiliary valve acting as a sort of relay. It must be remembered that there is no mechanical connection between the main valve and the spindle, so that the former does not in any position exert the slightest pull on the latter.

The form of the passages in the tubular throttle valve is such as to provide a very gradual admission, and for 10 per cent. steam admission the valve has to move through 50 per cent. of its stroke. The valve face and seat are specially constructed so that the faces are protected by means of a projecting lip or edge from the cutting action of the steam at high velocity when the valve is opened or closed. Owing also to the particular design of the throttle valve there is no appreciable rush of steam past the faces of the main valve before these are drawn apart to a considerable extent.

The valve is also made for marine and stationary engines, and is also adapted for use as a pressure-reducing valve and emergency shut-off valve.

For boiler or superheater stop valves an improved expansion spindle has been introduced which obviates the strains which are set up where gun-metal spindles are used in valves which are constructed with cast iron or steel bodies. This is said to dispense with the danger of bending or breaking the spindle, distorting the threads, or jamming the valve, a mischance which creates strains sufficient to fracture the body and lid by the unequal endwise expansion of the spindle over that of the valve body. The valves which are made by J. Hopkinson and Co. have seatings of a special alloy, to which they have given the name "Platnam," which neither softens nor deteriorates at high temperatures, is non-corrodible, and is specially adapted to withstand superheated steam. It practically does away with differential expansion, and there is consequently no liability of the seatings to warp or become out of shape or leave the valve body. This alloy is considerably harder than Admiralty bronze, and is, in fact, as hard as nickel steel, containing 4.25 per cent. of nickel.

The valves, which are fast on the spindle, are perfectly controlled by the guide on the lid. There is thus no chattering nor coming off of loose valves. Another type of valve is the "centre-pressure," in which the pressure exerted by each of the internal valves when closed is always to the centre of the body, the action being obtained by a novel arrangement of spindles and floating bridge. The main valve and its seating are fully protected from the cutting action of the steam, the valves are independent and separately and positively operated, and cannot chatter. The makers say that a 12in. bore centre-pressure stop valve, fitted with a standard hand-wheel 22in. in diameter, was easily closed by one man without any additional aid against a 200lb. pressure, and moreover, when closed, was perfectly steam-tight, and remained so even when the pressure and temperature were reduced.

The parallel slide valve made by the same firm is worthy of notice, inasmuch as with it there is no wedging action, which is held to be injurious, and the valve is held to its seat in equilibrium of pressure and in opening and closing slides on the same with a uniform flexible pressure. The tendency for dirt and sediment to lodge between the seating and the face of the valve is therefore lessened, and as the discs rotate on their axes, instead of moving up and down in a uniform path, there is no tendency towards grooving. The flexible pressure between the valve and its seat mentioned also prevents any liability to cut or score the valve faces.

One of the most recent and improved forms of alternatives to valves of the full-bore pattern is the Hopkinson-Ferranti patent stop valve, of which, by the courtesy of the makers, illustrations are given. The valves are designed to pass an amount of steam equal to the full carrying capacity of the piping with working parts of only half the usual diameter. The idea is that of the converging-diverging nozzle, and is so simple that it is remarkable that a valve designed on these lines has not been put on the market before. The working parts, as will be seen, are in the throat of this nozzle, and by the special construction of the valve a smooth passage is provided for the steam when the valve is full open. The explanation of the action is said to be as follows:—A portion of the pressure-energy of the steam as it travels into the converging nozzle on the inlet side is converted into kinetic energy, the steam increasing in velocity and dropping in temperature and pressure. At the high velocity thus acquired it passes through the controlling part of the valve, after which it enters a diverging nozzle at high velocity, and in its passage the kinetic energy is converted back into heat and pressure until it has returned to the same conditions of temperature, pressure, and velocity as before it entered the inlet side of the valve, into the converging cone.

Briefly, the advantages of this valve are as follow:—The possible leakage of steam is halved, as the perimeter of the valve disc and seat is one half that of the usual form of valve. The reduction in the size of these parts also reduces the warping with superheated steam, still further reducing the possibility of leakage. There is only one-eighth of the work to do in opening or closing the valve; the opening is gradual, and no by-passes are required for valves below 12in. bore. All expansion and contraction, whether endwise or sideways, is provided for, and the valve cannot jam under any circumstances. All the good features of Hopkinson valves are retained, and when the valve is open and working the seats are sheltered from the steam flowing along the pipe.

There are many other forms of stop and pressure-control valves, &c., which might be dealt with, but the principal differences in action and construction have now been treated fairly exhaustively. The thanks of the author are due to the various firms who have supplied illustrations and details of their valves, and his apologies are also due to those firms who so kindly offered, and supplied, material which, through pressure of space, he has been unable to use.

G. Basil Barham, A.M.I.E.E.

THE TESTING OF GALVANISED IRON.

THE ordinary tests necessary for gauging the quality of the galvanising or zinc-coating on iron sheets, wires, or finished articles should, so far as commercial requirements are concerned, indicate the thickness, uniformity, and purity of the zinc covering, and its ductility and hardness; it is also necessary that the galvanising be shown to be perfectly continuous over the surface and free from pin-holes, &c. Considering that there are three methods of galvanising in general use and that each method gives a widely different result as regards the nature of the zinc-coating produced, there is need for adapting the tests to suit the particular galvanising process which has been adopted.

The three galvanising processes in common use to-day are: Hot galvanising, in which the clean iron is dipped into a bath of molten zinc; cold galvanising, or the "wet" process, which consists in electro-depositing the zinc from a zinc salt solution; "Sherardising," viz., the dry process discovered by Sherard Cowper-Coles, which consists of tumbling or agitating the articles to be treated in a heated mixture of finely-divided zinc and zinc oxide. In the course of a paper read by Dr. W. H. Walker before the American Society for Testing Materials the author indicated the difference in the finished product yielded by these processes and made experiments with the object of showing the necessity of suitable commercial tests for the quality of each. A polished oblique section of ordinary hot-galvanised iron when etched with iodine reveals three distinct layers. First, a coating of zinc, which varies in thickness according to the temperature of the zinc bath and the amount of squeezing or wiping applied to the article before the zinc solidifies; second, a distinct layer of a zinc-iron alloy, termed alloy B, which varies in thickness with the temperature of the zinc bath and the length of time the iron is subjected to it; third, the iron base itself. Between the zinc and alloy B there is generally a second alloy, alloy A, which is a thin, discontinuous layer, richer in zinc than alloy B, and between the iron and alloy B is a third alloy, relatively unimportant, which is very rich in iron, alloy C.

Sherardised iron also presents a relatively complex structure. The metallic zinc penetrates the iron, forming deep layers of the alloys B and C, and in place of alloy A there occurs a number of compounds, as yet unidentified. Upon the surface there is generally a layer of relatively pure zinc, although frequently the process is carried to the point where only a deep layer of alloys is formed. When examined under the microscope this alloy is seen to be covered with deep cracks or fissures, as though the alloy in forming had contracted.

The structure of wet-galvanised iron is comparatively simple, the layer being practically pure zinc.

Although there is such a marked difference in appearance and in structure between these three kinds of zinc-coated iron, only one method of testing them has been used, namely, the "Preece" or copper-sulphate immersion test. This test is essentially as follows: A standard solution of copper sulphate is prepared by agitating a nearly saturated solution of this salt with copper oxide until it is perfectly neutral. It is then diluted to 1.186sp.gr. at 65deg. Fahr. When a rod of zinc and one of iron are placed in this solution the metals pass into solution as soluble sulphates, an equivalent weight of copper being at the same time deposited on the metallic rods. The copper deposited on the zinc surface is black, spongy, and easily removed, while on the iron it is dense and of a bright colour. When this reaction is used in testing galvanised iron it is assumed that the speed of solution of the zinc is a direct function of the time of immersion, and by the number of one-minute immersions necessary to dissolve the zinc from the iron and to deposit a film of bright copper thereon the thickness of the zinc can be estimated. It will be seen that this method measures the thickness of the coating only at its thinnest point, and that the assumption is made that no bright copper will be formed until the iron base is reached.

The corrosion of pure zinc in water is very slow. If, however, the zinc is in electrical contact with any material upon which the hydrogen can be liberated, the corrosion of the zinc is relatively rapid. The iron-zinc alloy B, and iron itself, are both surfaces on which this depolarisation action can take place, and hence, so long as neither the iron nor the alloy is exposed, other things being equal, the zinc coating will not corrode. The importance, therefore, of maintaining a uniform coating of zinc upon the iron can be appreciated.

To determine whether the ratio of the time of immersion required to produce a bright copper surface was in reality a measure of the thickness of the zinc coating samples of galvanised sheets were obtained and tested by Dr. Walker at the Massachusetts Institute of Technology. The weight of zinc per square inch area was determined by dissolving the zinc from the sheets without attacking the iron-zinc alloy. This can readily be accomplished by heating the galvanised sample, together with a piece of metallic iron, in boiling caustic soda until the generation of the hydrogen ceases. As might be expected, the ratio between the time of immersion required to show the presence of bright adherent copper and the amount of zinc present per unit area depends upon the uniformity with which the coating of zinc is spread upon the iron base. In the case of fourteen pieces of galvanised sheet iron, for example, the average ratio found was twenty-three, while the greatest variation in either direction was but twenty. This test, therefore, so far as indicating the uniformity of the coating and measuring the thickness of the zinc are concerned, is fairly satisfactory; but alloy B is always indicated as iron, and hence, when the test is applied to Sherardised articles, very erroneous and misleading results may be obtained.

The presence of the channels or pin-holes caused by the free iron surface coming in contact with the zinc and causing it to pass into solution cannot be detected by the copper-sulphate method, as these pin-holes down through the zinc to the iron fill up with black, spongy copper and cover up the bright copper spot at the bottom. The purity of the zinc cannot be determined, as the bright copper particles precipitated by this method are so small that they are lost in the mass of black, spongy copper. Nor can the toughness or the ductility of the coating be determined, due to the same tendency of the spongy copper to cover up the bright copper deposits, which indicate cracks extending down through the zinc coating to the alloy or iron underneath.

The relation between the presence of pin-holes in the zinc surface and cracks due to a brittle coating and the durability of the structure as a whole has heretofore not been studied, largely because no method of detecting these imperfections has been available. The following phenomenon serves as a basis for such a test. If a piece of zinc be placed in a strong solution of caustic soda heated to about 100deg. C. no action is noticeable. If now the zinc be touched with a piece of iron, hydrogen is liberated in great volume from the iron. Small cracks in the zinc coating may be easily detected in the same way.

Ordinary hot-galvanised ware is generally very free from imperfections of this kind, while wet-galvanised ware, on the other hand, is frequently very porous, generating hydrogen at numberless small points over its entire surface. Theoretically, the best electroplated surface should be that carrying the greatest weight of zinc per unit area, deposited at the slowest rate. That is, the lower the current density at the cathode in plating the less porous will be the deposited metal, and the thicker this dense deposit is the better protection will it be. A great many tests on electroplated zinc-coated iron were made, the samples varying in both these particulars. In every case, those deposited most rapidly were the most porous, and the results showed that the time of plating was more important than the weight of zinc per unit area, although there was a minimum below which it was not safe to go.

As the rapidity of hydrogen generation from zinc is a function of the presence of an alloy of zinc and iron, hence the more impure the zinc coating the more impure will be its solution in acid. Accordingly, the impurity of the zinc, the presence of pinholes and cracks, and the thinness of coating are all factors which act in an accumulative way to increase the rate at which hydrogen is generated when the zinc surface is exposed to acid. This method has been developed by Mr. C. L. Campbell, and is found to give very concordant results. The apparatus employed may take any convenient form, it being but necessary to expose a known area of the zinc coating to a standard acid solution under uniform conditions and to measure the hydrogen generated per minute. In almost every case a sharp maximum is reached giving the resultant of all the different factors which make for rapid dissolution of the zinc. Thus, in a series of wet-galvanised sheets, those electroplated for 15min. reached a maximum of 7 cu. cm. in 3min.; those plated for 30min. a maximum of 14 cu. cm. in 10min.; while those plated for 45min. showed a rather poor maximum of 6 cu. cm. in 30min. In many samples of Sherardised product there were two maxima on the curve showing the amount of hydrogen generated per minute. This indicates that there is first an action between the outside zinc coating and the iron-zinc alloy, and later a well-defined action between the alloy and the iron.

Service tests with galvanised iron are of necessity very slow at best, and the relation of the above test results to the real durability of the material can be determined only after a number of years. Something can, however, be learned by the study of ware which has already been exposed for sufficient time to determine its durability. Most of the material available for the purpose was in the form of fence wire; from a study of these examples the following conclusions were drawn:—

First, thickness of coating. In every instance where a very durable fence was found the coating of zinc proved to be relatively very thick. On the other hand, the wire fences which showed marked corrosion in from one to two years proved to have almost no zinc on the iron, the zinc colour being due to a layer of alloy alone. It is doubtless true that the purity of the iron used in the wire itself plays an important part in determining the ultimate durability of a fence, yet it would appear that the thickness of the zinc coating calls for more immediate attention. The modern method of a close mechanical wiping of the wire as it emerges from the zinc-bath produces too often a wire covered not with zinc, but only with a thin layer of electro-negative iron-zinc alloy, which affords but little protection to the iron. To produce a wire with a liberal coating of zinc would, of course, cost more, both on account of the extra zinc and on account of a somewhat smaller production per machine.

Second, purity of zinc. It is probably a necessary consequence of hot galvanising that the zinc becomes somewhat contaminated with dissolved iron. It is apparent that this should be kept at a minimum in order that the coating should be of maximum durability.

Third, flexibility of the zinc coating. The important objection to placing a thick coating of zinc upon wire used for fencing is that such a coating cracks off when running through the machine. This objection applies only to those wires which are subjected to very sharp bends or turns. It is possible that by passing the zinc-coated wire through dies or under grooved rolls the crystalline condition of the zinc could be destroyed and the flexibility and ductility materially increased.

The following is the summary of the experimental results arrived at by the author :—

1. The copper-sulphate immersion test is of value in determining the uniformity of coating and relatively the thickness of coating in hot and in wet galvanising products; but it is worthless in the case of Sherardised products, and gives no idea of other important factors involved in the durability of the structure.

2. By immersing a galvanised product in hot, strong caustic soda the presence of any unprotected iron may easily be detected, however small such area may be.

3. The weight of zinc per unit area apart from the zinc-iron alloy may be analytically determined by dissolving the zinc from the plate through treatment with hot caustic soda while in contact with metallic iron.

4. Theoretically, the rate at which hydrogen is evolved when the galvanised product is immersed in dilute acid should indicate its relative durability; inferior products should reach a maximum in a few minutes compared with a much longer time for better products.

5. In the very important matter of fencing wire, while the purity of the iron used is of consequence, a more immediate necessity is a heavier coating of zinc on the wire.

6. The flexibility of a zinc-coated wire may possibly be increased by mechanically working the wire in rolls or dies to destroy crystallisation in the zinc coating.

THE OERLIKON STEAM TURBINE.

For many years after steam turbines had evolved from the experimental into the commercial stage there was a widespread idea among the engineering community that the reaction turbine was the only possible one for anything except the very smallest powers, but of late years a better understanding of the manifold difficulties connected with the design of turbines has led many to the conclusion that the action or impulse type will predominate in the future. There is no doubt that the reaction type is at a serious disadvantage in many respects, particularly as regards the construction and efficiency of the high-pressure end, its liability to stripping, and its comparatively great length, while it is redeemed, to some extent, by the efficiency of the low-pressure end. In fact, it may roughly be said that, as far as steam consumption is concerned, it gains in the last expansion what it loses in the first two. The cause of the inefficiency in the high-pressure end is obvious, since the diameter of the spindle or the height of the blades must be made small in the first row in order to prevent the steam expanding too rapidly. The diameter cannot, for constructional reasons, be reduced below a certain limit, and hence the blades are short, which means that the clearance is relatively great, and consequently the leakage of steam over the tips, without doing useful work, is very considerable. In the impulse type, where the steam only expands through a few nozzles around the periphery, the diameter at the high-pressure end may be as large as desirable, and the expansion of the steam carried out by increasing the number or size of the nozzles instead of enlarging the diameter of the cylinder. As expansion of steam takes place only in the nozzles of an impulse turbine, and not in its passage through the blades in the moving wheels, the pressure on the two sides of any wheel is the same, and no end-pressure on the spindle results; no balancing pistons are therefore required, and the turbine is consequently much shorter.

The Oerlikon turbine is of the purely impulse type, and was originally constructed on exactly the same lines as the Rateau turbine; but in the last few years several important modifications have been made in the design and details of construction, which add considerably to its efficiency and reliability. There is, naturally, a certain similarity between all turbines of the one general type, and the Curtis, Rateau, Zoelly, De Laval, Oerlikon, and A.E.G. types are all built on somewhat analogous lines, each having its particular variations.

A sectional view of an Oerlikon turbine is shown in Fig. 1, and an exterior view of a 1000kw. turbo-alternator in Fig. 2. The turbine is of the multi-stage type, each stage consisting of one set of nozzles and one moving wheel, differing in this respect from the Curtis, in which a complete stage comprises one set of nozzles and a few rows of fixed and moving blades. In the Oerlikon turbine several stages go to form one complete expansion, and there are usually two or three expansions altogether. The number of rows of blades is much less than in a reaction turbine, as a relatively larger amount of work is done in each step, and the speed of rotation is on the whole slightly higher, which is made possible by careful attention to the design of the moving wheels. The shaft is stepped both ways from the bearings and has its largest diameter where the greatest stress will come upon it, that is, near the centre, but slightly towards the

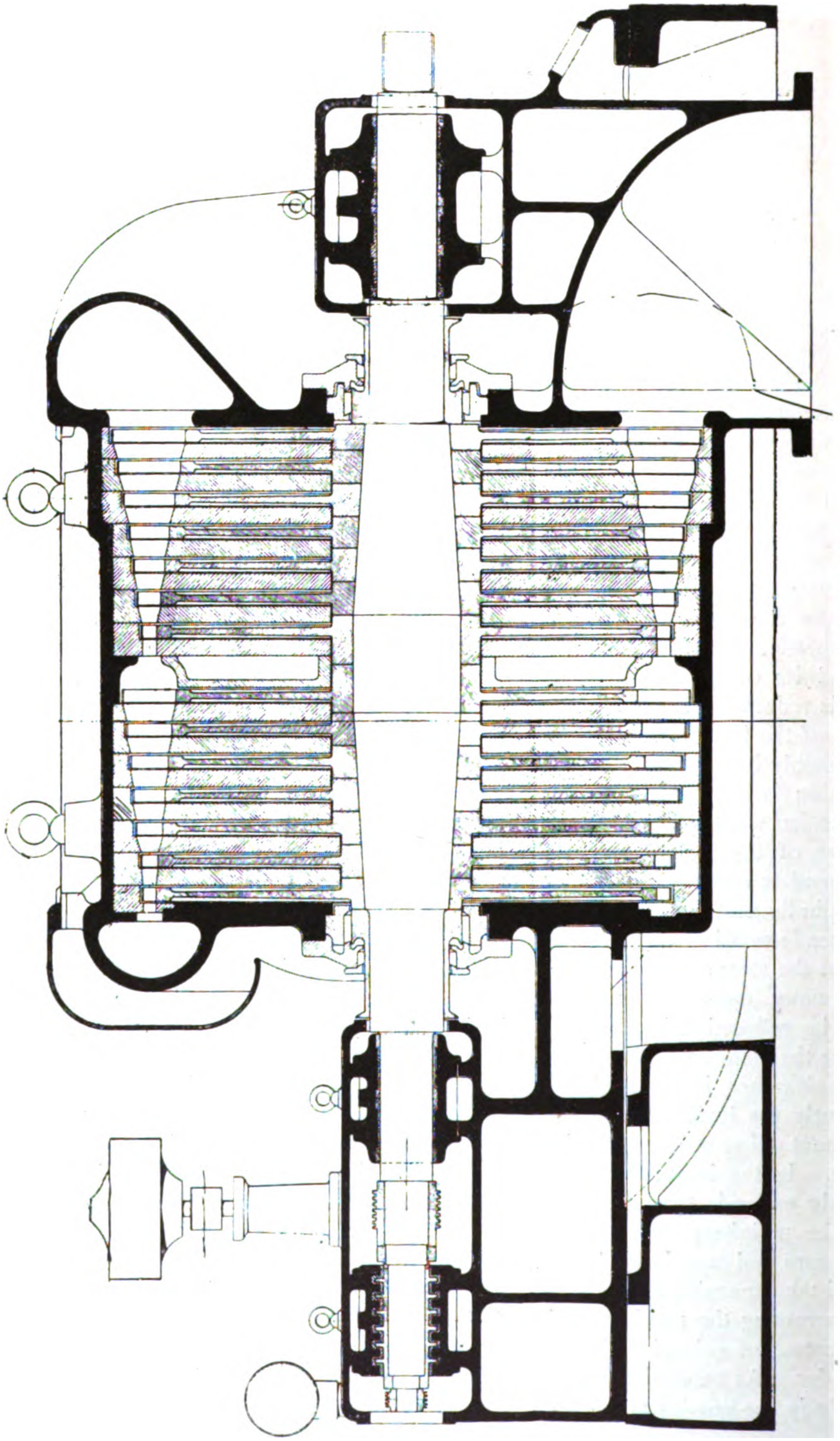


Fig. 1. Sectional View of Oerlikon Turbine.

exhaust end. All the wheels, which are merely forced on and held by keys, can thus be readily removed in case of necessity, and as they are carefully balanced before being fitted on the shaft there is no trouble as regards running when the machine is put to work. The wheels consist of forged steel discs, thickened at the rim and dovetailed to receive the blades. The blades fall right to the bottom of the slots, as is clearly shown in Fig. 3, the distance-pieces between each pair of blades are firmly held by rivets, and only extend to about half the depth of the groove. At the top the blades are all rivetted singly on to a ring, thus forming a very compact and strong arrangement and preventing any dispersal or leakage of steam. In the reaction turbine, where the spindle is made of several drums shrunk on each other, its strength can only be tested after the whole is built up complete, and any defect due to lack of homogeneity in the steel means doing away with the finished spindle. With the Oerlikon turbine, on the other hand, each wheel is complete in itself and is tested by running up to 50 per cent. over the normal speed, so that the spindle requires practically no balancing. Two wheels for turbines of different sizes are seen in Fig. 4, and their construction and the method of fixing the blades are illustrated in Fig. 3. The blades are made of nickel steel, and are capable of withstanding a high degree of superheat without damage, which is a very important consideration in view of the great increase of efficiency in steam turbines when superheat is employed. As there is no difference in pressure on the two sides of a moving wheel

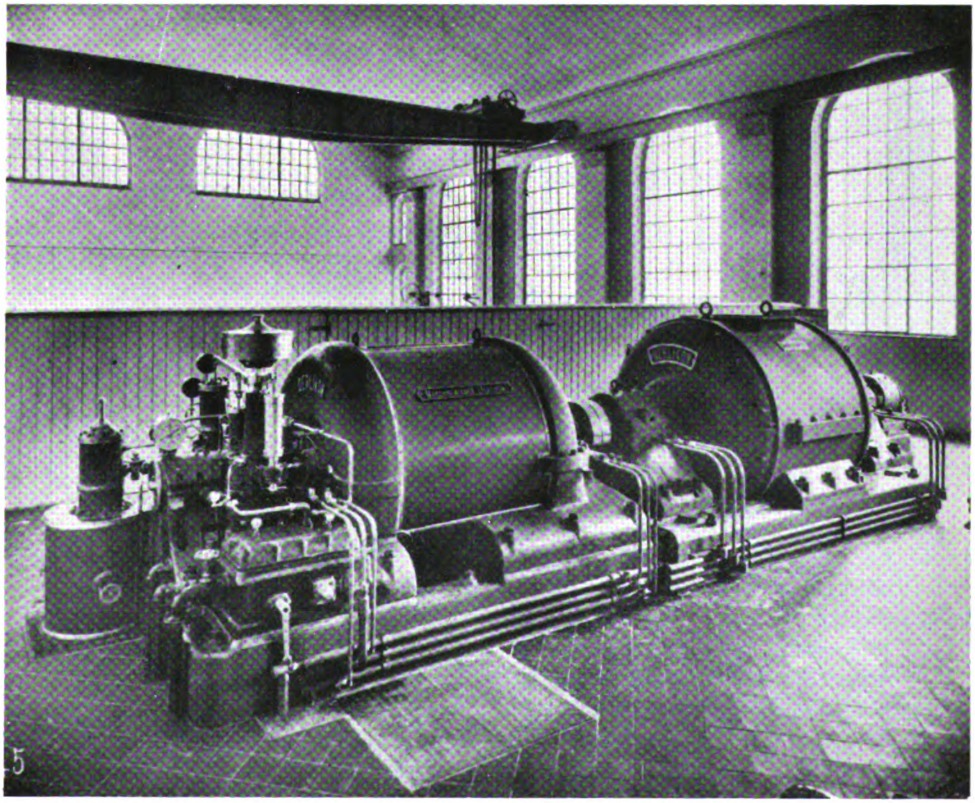


Fig. 2. A 1000kw. Turbo-Alternator.

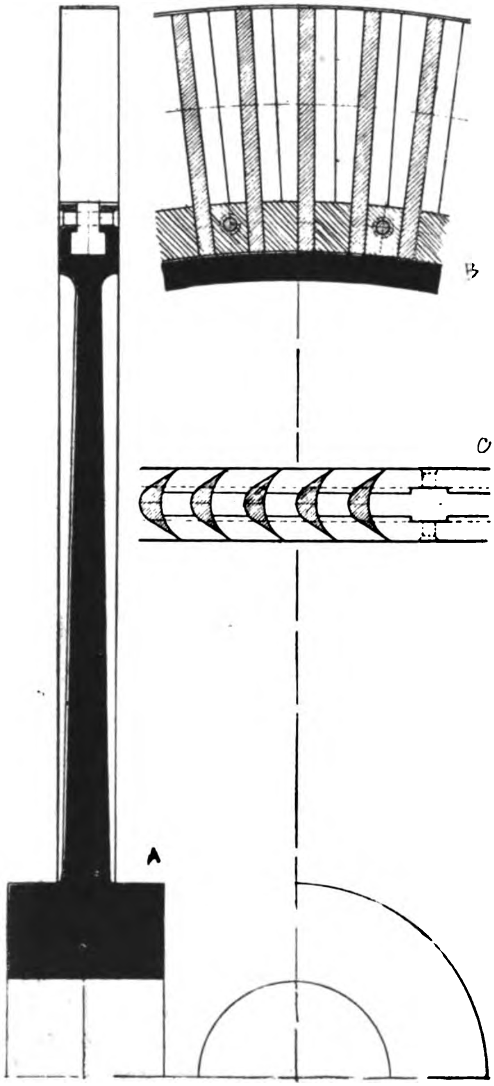


FIG. 3. CONSTRUCTION OF WHEEL AND BLADES.

the clearances between the spindle-blades and the cylinder may be relatively large, and in the Oerlikon turbine it is commonly 0.12in. to 0.15in., as compared with 0.025in. to 0.04in. in reaction turbines of equal power. The danger of stripping is thus much diminished, and, indeed, is said to be quite unknown with this turbine.

A distinctive feature of the Oerlikon turbine, in which it differs radically from others of the impulse type, is that the heights of the fixed and moving blades increase continuously throughout each expansion, and that all the fixed blades, except the first row in the expansion, are conical, and so form diverging nozzles. The height of the fixed blades at the exit of the steam is the same as that of the moving blades in the next row. The result of this is that, without increasing the number of nozzles per row in one expansion, the steam expands regularly, and the peripheral length of the steam admission area remains the same throughout; with the ordinary multi-stage impulse turbine the nozzles are of equal area, but increase in number as the steam expands. The blade-heights increase until limited by constructional reasons, when a new expansion commences, with very much smaller blades, but a larger number of them, so as to give the required area to ensure the further drop of steam pressure, and in each expansion the same arrangement is adopted until the exhaust end is reached; the number of expansions is usually two or three, each consisting of about seven stages. As a result of this construction the steam, on emerging from the blades of a moving wheel, can enter the diverging nozzles of the next diaphragm and expand immediately with much less likelihood of its velocity being diminished owing to its spreading in a radial or peripheral direction. In other words, the velocity of the steam as it leaves a moving wheel is at once made use of in the nozzles, and does not fall to zero between the nozzles and the moving blades. This is shown diagrammatically in Figs. 5 and 6, Fig. 5 illustrating the action of the steam in an Oerlikon turbine and Fig. 6 that in an ordinary impulse turbine. In the former there are two expansions or pressure stages, and the height of the blades increases from 0.31in. to 2in.; the second expansion begins with a blade height of 0.6in., the last row being 1.92in. The peripheral length of steam admission in the diaphragms of the first expansion is 16 per cent. and in the second 90 per cent. of the whole circumference. The fall of pressure of the steam in its passage through the turbine is shown in the diagram, the admission pressure being 150lb. per square inch and the exhaust 1.5lb. per square inch absolute, or a vacuum of 27in. From this drop of pressure for a given speed of rotation the curve *c*, showing the variation of velocity of the steam, is obtained, the nozzles being so designed as to give similar variations of speed throughout the whole expansion. The peripheral length occupied by the nozzles is indicated at *b*, from which it is seen that it remains constant during each expansion.

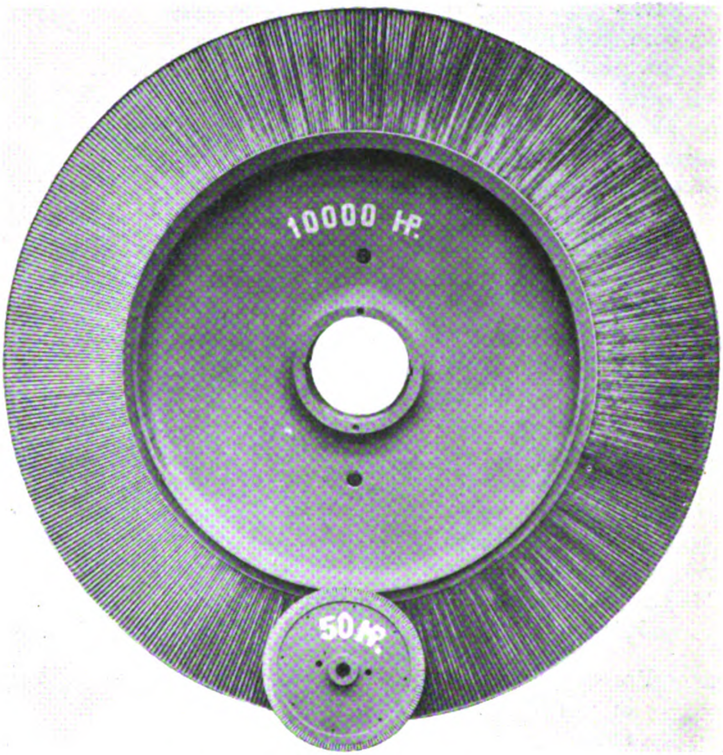


FIG. 4. TWO COMPLETE TURBINE WHEELS.

In Fig. 6, representing the usual impulse turbine, the blade heights do not alter in any one expansion, but the peripheral length of the nozzles increases to give the required drop of pressure—that is to say, the number of nozzles increases. The curve of variation of steam velocity *c* shows that the velocity on emerging from the moving wheels is completely lost. It is obvious that this is a disadvantage, and the Oerlikon turbine, in making use of all the available energy of the steam, gains considerably, and is able to add very much to its reliability of operation. By preventing the velocity of the steam dropping to zero after leaving the wheels a larger amount of work might be obtained from the same weight of steam and the efficiency of the turbine consequently increased. But in view of the absolute necessity of reliability in steam turbines the Oerlikon Company sacrificed this gain of efficiency in order to add to the reliability of running, so that these turbines, while being quite as economical as other impulse turbines, are claimed to be much less liable to breakdown. This immunity is obtained by having a large radial clearance between the central bore of each diaphragm and the hub of the wheel revolving within it, this being the only portion of the turbine where contact is at all likely to occur, since the clearances must be relatively small owing to there being a difference of pressure on the two sides of the diaphragm. In most impulse turbines this clearance is only 0.01in. to 0.02in., while in the Oerlikon turbine it is at least 0.04in., and may be as much as 0.1in. in very large machines, so that this turbine may be said to be practically proof against stripping.

Several experiments have been carried out to prove that useful effect is actually obtained from the velocity of the steam as it leaves the moving wheels. It is well known that in ordinary impulse turbines the steam consumption remains almost constant (or decreases very slightly) when the speed of revolution is diminished, whereas with a reaction turbine, where the exit velocity of the moving blades is usefully employed in the fixed blades, the steam consumption increases with a decrease of speed. If, therefore, this latter effect occurs in the Oerlikon turbine it shows that the exit velocity of the steam does useful work in a similar manner.

The following results were obtained in a typical test on an Oerlikon turbine of 1000kw. running at a normal speed of 3000 revolutions per minute. The symbols used are given below :—

P1 = Pressure of steam in front of the first set of nozzles in lbs. per square inch absolute.

T1 = Temperature of steam in front of first set of nozzles in degrees Fahr.

P2 = Vacuum in inches of mercury.

N = Revolutions per minute.

D = Pounds of steam used per hour.

B = Power delivered by the generator in kilowatts.

K = Consumption of steam per kilowatt-hour.

P1	T1	P2	B	N	D
91·5	540	27·4	526	3000	11,600
91·5	548	27·6	518	2677	11.650
91·5	548	27·6	465	1700	11,850

It is evident from this that with the same range of pressure the steam consumption increases with decrease of speed of revolution, showing the useful effect of the exit velocity of the steam from the moving wheel. The

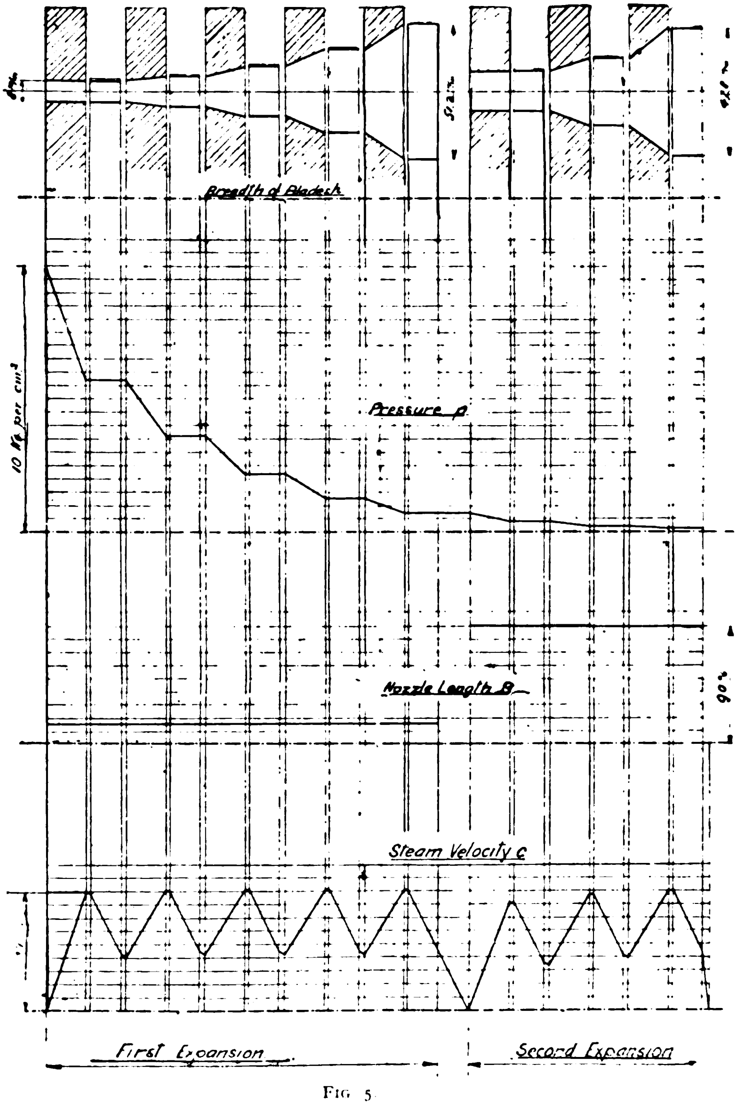


Fig. 5

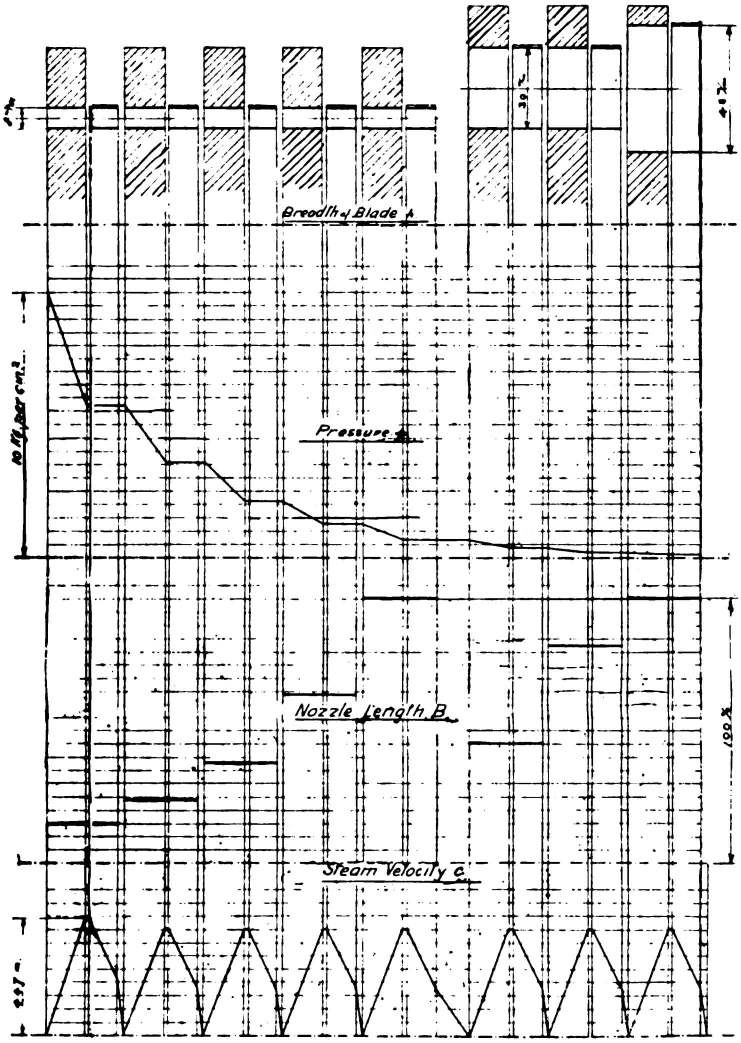


FIG. 6.

following table gives the complete results of this machine :—

P1	T1	P2	B	N	D	K
53	496	28.4	305	3000	7,520	24.6
75.5	487	28.4	499	3005	10,600	21.3
104	495	28.1	765	3010	15,150	19.9
138	514	27.6	1004	3000	19,150	19
167	534	27.1	1243	3000	23,050	18.5

The radial clearance between the spindle and diaphragm is in this case 0.05in., that between the moving blades and the cylinder is 0.16in., while the axial play between the diaphragms and the wheels is 0.12in. to 0.2in. In spite of these large clearances the steam consumption per kilowatt-hour is equal to the best results obtained by turbines of the same power, and the reliability of running is much more certain than usual.

Oerlikon turbines are now invariably made in one cylinder up to 20,000 h.p., and two bearings only are used, a thrust block taking up what end pressure may exist, as is seen in Fig. 1. A small rotary oil-pump driven by a worm on the spindle supplies oil to the bearings at a pressure of from 5lb. to 10lb. per square inch, while for very large powers water cooling is also employed. As is now common with large impulse turbines, the blades forming the nozzles in the Oerlikon turbine are cast in the periphery of the diaphragms, which are cast or forged with a thickened rim or hub. These are joined on both sides with thin steel discs in order to diminish the friction of the steam on the surfaces. The blades are similar to the moving blades, and are of nickel steel.

The governing of steam turbines is a point on which the last word will, seemingly,

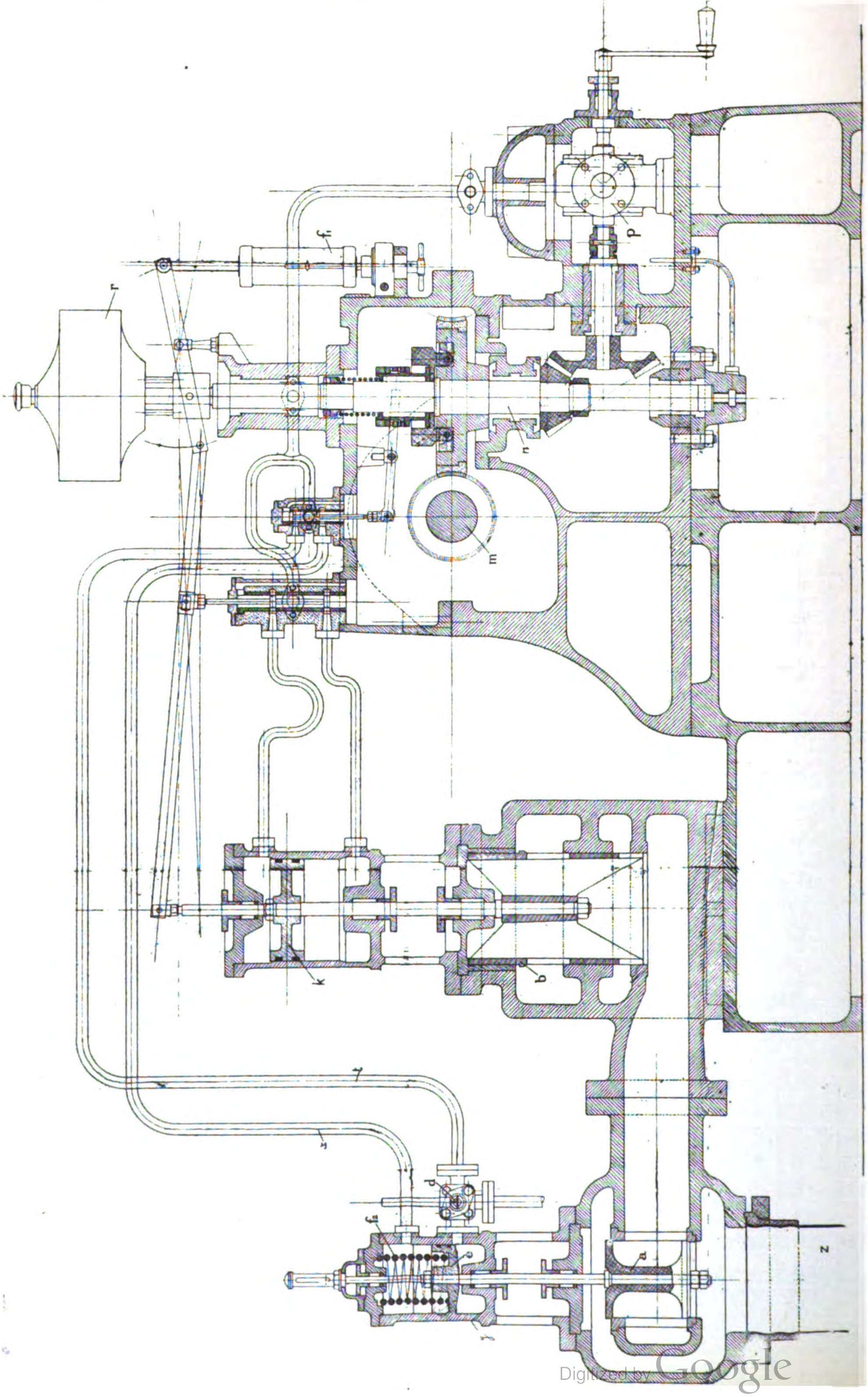


Fig. 7. Governor Gear of the Oerlikon Turbine.

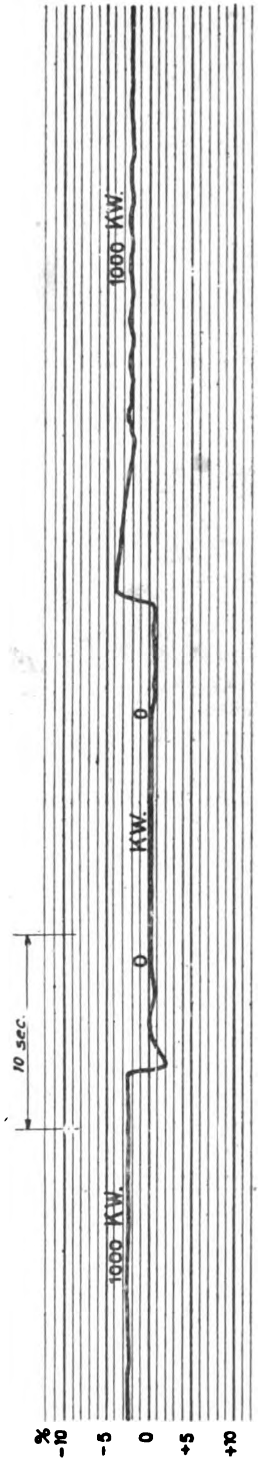


Fig. 8. Showing Regulation of Turbine with Sudden Changes from Full-Load to No-Load.

never be said. Each type of regulator has its adherents who cannot, or will not, understand why other makers do not adopt the same principle. The Parsons blast governor, by means of which steam is admitted in puffs, is very generally used for reaction turbines, although some makers (Willans and Robinson, for instance) employ the ordinary throttle governor with apparently good results, while with the impulse turbine governing by variation of the nozzle area and also by throttle of the main steam pipe are both in evidence. The Oerlikon Company adopt the latter type, but the method of operation is somewhat unusual. Fig. 7 shows the general arrangement of the system, *z* being the pipe through which the steam enters the turbine and *a* the main double-beat stop-valve, the valve spindle being prolonged as shown. On it a piston *e* is fixed by a nut, and kept in position by the spring *f2*, which in the ordinary way forces the piston down and keeps the valve on its seat. Oil under pressure is supplied by the pump *p*, driven off the turbine shaft, and passes into the pipe *t*, which has a three-way cock *d* on it. When this cock is turned to the position shown in the figure, it allows oil to enter the relay cylinder *v* under the piston *e*, which it forces up against the spring *f2*, and so raises the valve *a* and admits steam to the turbine; *r* is the governor, the spindle *n* being driven off the turbine shaft *m* through worm gear. The steam after passing through the stop-valve *a* is regulated by the throttle valve *b*, which in a similar manner is operated by oil pressure admitted above or below the small piston *k* fixed on an extension of the valve spindle. When the speed varies the governor balls move inwards or outwards and work the lever attached to the governor sleeve. By means of a plunger fixed to the middle of the lever (as shown) oil is directed above or below the main piston *k*, which it raises or lowers according to the movement of the lever on the governor spindle, *i.e.*, according to the speed of the turbine. The throttle valve *b* is thus opened or closed according as the

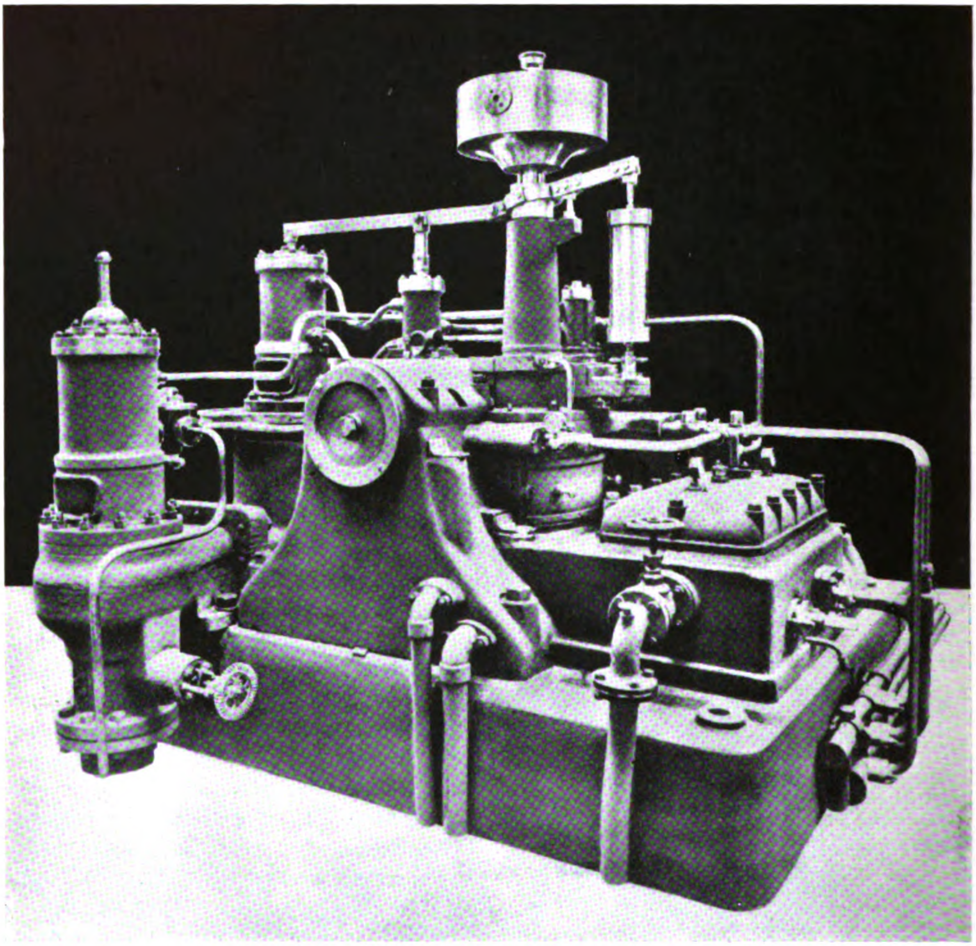


Fig. 9. View of Turbine Governor Gear.

speed falls or rises. The safety governor operates in a similar manner from another lever on the governor spindle, and allows oil to enter the pipe *x* on the top of the piston *e*, thus closing the valve *a* completely and shutting down the turbine. An advantage of the operation by oil pressure lies in the fact that should the oil fail for any reason, the spring *f2* forces the piston *e* down, since there is no longer an oil pressure underneath, and the valve *a* is closed. This is a very important point, because to run a turbine without oil for even a short time is most disastrous.

The very good regulation of which this governor is capable is shown in Fig. 8, representing the variation in speed of a 1000kw. machine when the full load is thrown on and off. It will be seen that the temporary decrease of speed when the load on the alternator was changed suddenly from 1000kw. to zero was under 5 per cent., while the permanent rise was only $2\frac{1}{2}$ per cent., results which compare favourably with those obtained with any type of governor. Fig. 9 shows a general exterior view of the complete governing gear.

A. P. Chalkley, B.Sc.

THE BRUSIO HYDRO-ELECTRIC SYSTEM.

ONE of the most important hydro-electric transmission systems of the world is the Swiss-Italian scheme now in operation, having its power-generating centre at Campocologno, Switzerland, and its distributing area over the Italian frontier. The water supply is drawn from Lake Poschiavo, which has an area of 2,400,000 square yards and an average depth of 260ft., by means of a syphon. It is then led by way of a tunnel driven through solid rock for a distance of three miles to a storage reservoir situated about 1450ft. above the site of the power house. The pipe lines from the reservoir to the power house are six in number; each is about 4500ft. long, and consists in the upper (low-pressure) lengths of riveted steel mains, the lower portions (for pressures above 20 atmospheres) being of welded tubes. Each pipe line is 30in. in diameter, and has a wall thickness varying from 6mm. to 23mm. At every bend or change in gradient the water mains rest on concrete blocks, but they are not secured to these, being left free in this respect to allow for shifts due to expansion and contraction. The hydraulic mains pass direct into the power house, entering a valve chamber where all can be connected to a collector. The turbines are of the Pelton wheel type, the larger sizes having a capacity of 3000h.p. to 3500h.p. at 375r.p.m., the smaller ones 225h.p. at 430r.p.m. In all cases the turbines are coupled direct to an electric generator by a Zodel-Voith flexible coupling. The main generators are 3000kw. three-phase alternators of the revolving field type. Current is generated at a pressure of 7000 volts, 50 periods, but voltage regulation from 6300 volts to 7800 volts is provided for to compensate for the transmission line losses. The exciting plant consists of separately driven units each of 150kw. capacity at 115 volts, and each capable of providing the necessary exciting current for four of the main alternators. In all, provision has been made for installing twelve main generating units, these being arranged longitudinally in the power house in equal groups of six each, the space between the groups being occupied by a central switch control column. This plant arrangement was selected, having in view that there are two main substations or distributing centres, and it was desirable to keep the two supplies entirely independent when deemed advisable or necessary. The principle of decentralising the switchboard arrangements has also been applied to the individual generating units, each alternator having a separate switchboard, placed alongside the machine, to itself. Each alternator switchboard is fitted with an oil-type circuit breaker, suitable for either hand or automatic action, usual synchronising apparatus, and a field switch of the de-exciting type connecting the alternator to a low-resistance induction coil. This switch is connected with a high-tension cut-out, so that the opening of the latter closes the de-exciting switch automatically. The generator switchboards are totally enclosed, the sides by concrete walls, and the front by iron doors; arrangements are also made for disconnecting the entire gear of the panels from the bus-bars, so that repairs and inspection of the connections and apparatus can be undertaken without personal risk. As will be seen from Fig. 2, the panels are set against the dividing wall behind which are the bus-bar chambers arranged on two floors—the exciting bars being on the lower level, the three-phase,

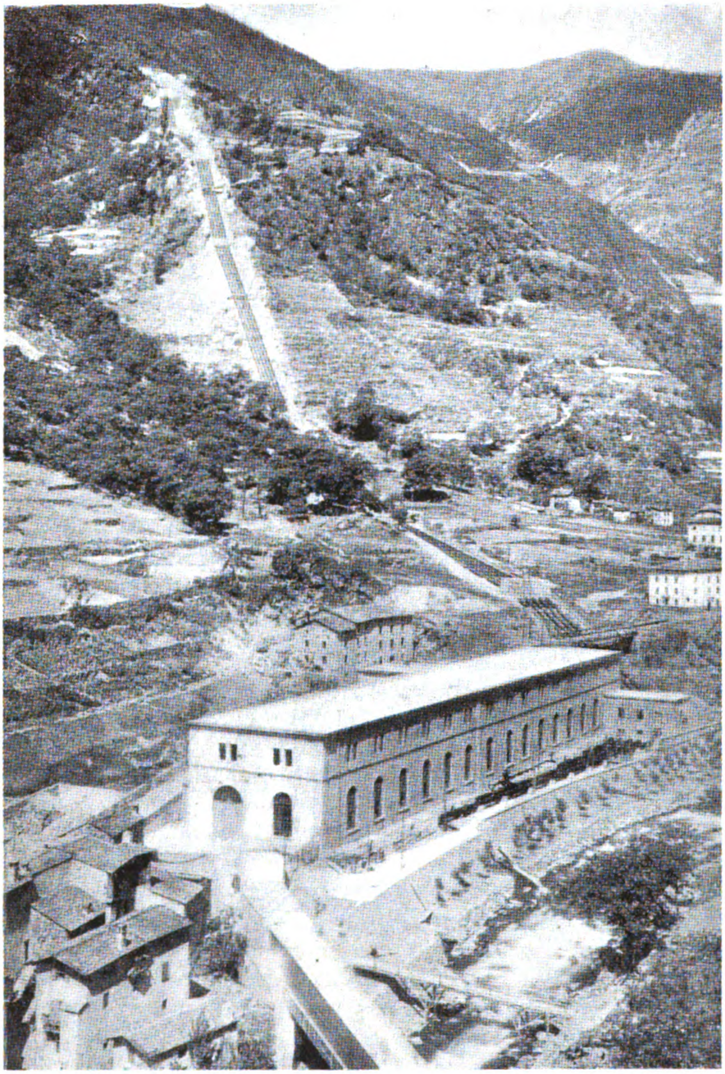


Fig. 1. The Power House and Pipe Line of the Brusio System.

exciter and feeder circuit are provided on the centre switch column. The sub-division of the generating plant into two separately controlled equal portions allows half of the station to supply the substation at Lomazzo, the other supplying the Castellanza substation; further provision is made for three of the generators being coupled to separate bus-bars for the supply of the Poschiavino district in the neighbourhood of the power house and the Bernina railway. In addition to this sub-division, which represents the normal running conditions of the plant, full switchboard arrangements are fitted to allow of the entire plant operating in parallel.

For the transmission lines the pressure of 7000 volts is stepped up to 45,000 volts, the transformers for this purpose being situated in a substation at Piattamala, which is about 700 yards from the central station and on Italian soil. The transmission line from the power house to the substation was one of the most difficult problems. An aerial line would have required 36 wires for the transmission of about 2400 amperes, and its upkeep did not promise too much safety on account of the possibility of falls. The use of underground cables would have involved

7000 volt bars being in the upper chamber. Whilst separate boards some distance apart are provided for each generating set, convenience of control is secured by means of the central switch column before mentioned, which, with the main exciter switchboard, is placed in the centre of the room and has master switches by which the whole of the plant can be regulated.

The necessary instruments for indicating the load conditions of every generator, an enormous cost, and the safety of the installation would not have been ensured. The most natural solution, and the one adopted, was a tunnel between the two stations in which to place the lines; but this solution met with the greatest opposition because the tunnel crosses the frontier and it was believed it would be used for smuggling. Two lines in the tunnel connect with the two sets of bus-bars of the two sections of the central station. On each side of the tunnel there are three lines of copper bars, one above the other, each 150mm. square. The bars are mounted on triple-petticoat insulators, which are fixed on straight supports between two U-shaped irons which serve at the same time to support concrete barriers between the different phases. The bare conductors on each side are separated from the central passage by a trellis of iron wire, so that the passage is always free from danger.

The tunnel is 2049ft. long, 6½ft. wide, and 9ft. 10in. high, and is watched night and day by custom-house officials. Most of the tunnel is dry; at one point only was found a spring of water, and the supply from this has been utilised to cool the transformers. The substation is designed to receive twenty-four single-phase transformers of 1250kw. each, which, star-connected in sets of three, raise the pressure from 7000 to 45,000 volts. The transformers are oil-insulated and water-cooled. The substation apparatus is arranged in duplicate throughout, provision being made for connecting the whole plant together should occasion arise. The building is about 180ft. by 68ft. by 26ft. high, and is surmounted by two towers for the outlet of the overhead transmission mains. The cable tunnel from the power house enters the basement, the conductors passing here into a meter room where the energy output is registered by means of a duplicate set of three ammeters, a recording voltmeter, a commutating voltmeter, and two recording wattmeters. The latter are of different types and arranged in series as a check to each other. The lines pass from the meter room to the transformers. Each group of three transformers has a high-tension, 70,000 volt three-pole automatic circuit breaker fitted with time-limit relay, and also a set of three single-pole oil switches on the outgoing side.

Small signal lamps are connected to each transformer to show when it is connected in circuit. In front and behind each transformer are choke coils, and the neutral wires common to the groups are brought to earth after passing horn-type lightning arresters. Each group can be separated on both sides

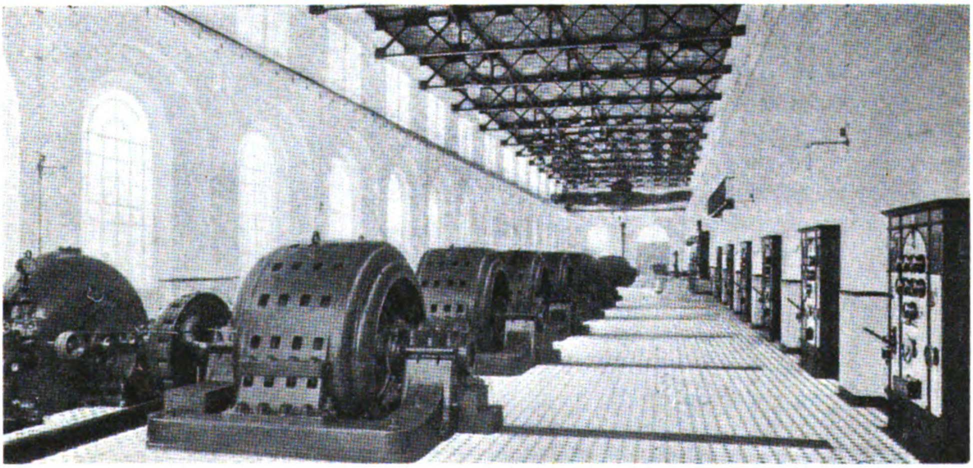


FIG. 2. INTERIOR OF GENERATOR HOUSE, BRUSIO POWER STATION.

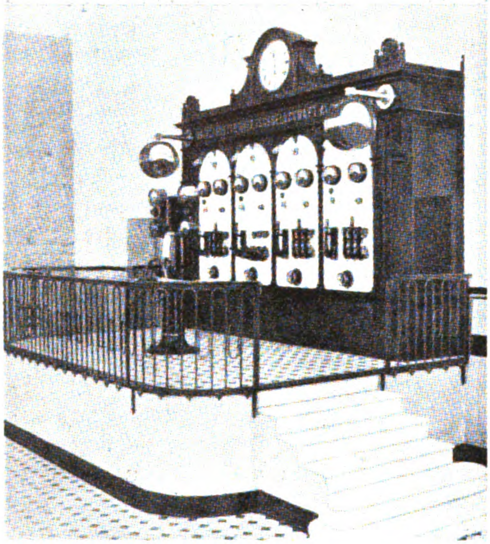


Fig. 3. Centre Control Column and Exciter Switchboard.

by cut-outs and put entirely out of service. All the lines are separated by walls and all the apparatus of each phase, except those for 70,000 volts, are placed in the same compartment with their switches. The transformers are mounted in the central part of the station, the whole length of which can be seen from the meter room. Each transformer is installed in a fireproof chamber which can be completely closed, except for a ventilating chimney, which in case of fire acts as a vent for the smoke of the oil.

From the transformer house at Piattamala to the substation at Lomazzo is a distance of 82 miles, the substation at Castellanza being twelve miles further on. The transmission system includes four parallel lines, each consisting of three copper cables 105 square millimetres in section. The conductors are carried on two parallel rows of iron lattice poles, six wires on each pole. The rows of poles are from 13ft. to 17ft. apart. In places where they are not so wide apart, from condition of the ground, the poles of one row are higher than those of the other by several metres, so that the proper distance between the two lines is maintained. The average height of the poles is 40ft., and they are set at intervals of about 328ft. apart. At some places the height of the pole is as much as 98ft., and in crossing certain valleys the span has been lengthened to 1312ft. Each wire is carried on porcelain insulators tested to 100,000 volts and spaced 47¼in. from each other. The insulators are mounted on straight supports fixed on blocks of wood carried on double iron supports. The line current when running without load, measured at the initial end, was about 14 amperes for each line of three wires, at about 50,000 volts potential. For the safety of the line there have been placed at Sondrio, Cortenova, at the commencement of the passage across the mountains; at Lecco, the commencement of the plain; and at Gerenzano, cabins containing lightning arresters.

The substation at Lomazzo constitutes the starting point for the distribution of the

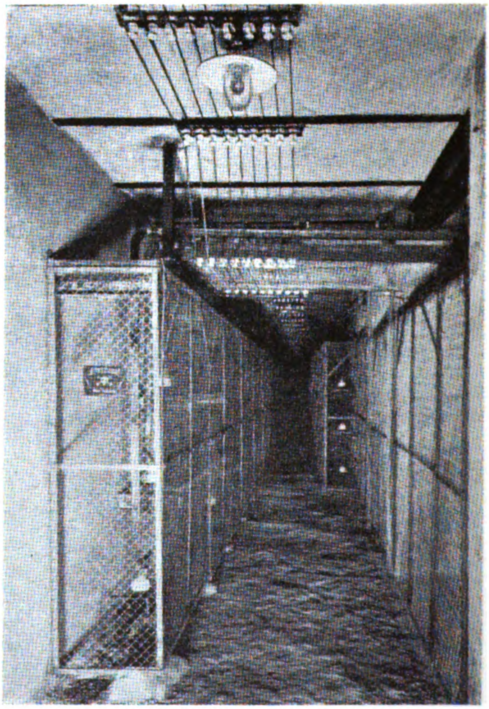


Fig. 4. The 7000-volt Out-going Feeders, Brusio Power Station.

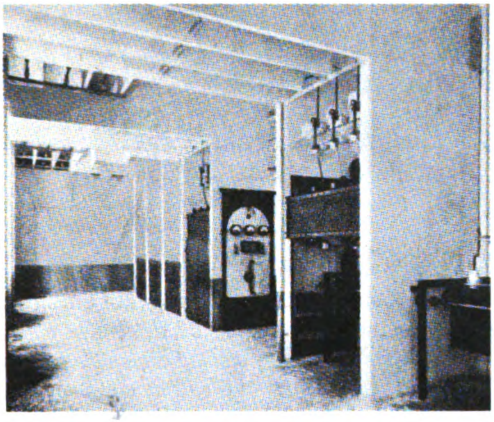


Fig. 5. The Step-up Transformer House at Piattamala.

power. It consists of an H-shaped building 124ft. long, 56ft. wide in the middle, and 32ft. high. It is arranged for the reception of six single-phase transformers, each of a capacity of 1250kw., to step down from 40,000 volts to 11,000 volts, and six three-phase transformers of 500kw., stepping up from 11,000 volts to 20,000 volts. At present there are installed three single-phase and three three-phase transformers.

This substation is remarkable for the facility of making line combinations. The two lines coming from Piattamala, called A and B, come in there, although generally only the line A supplies Lomazzo, while the line B is intended for Castellanza. A third line, C, connects Lomazzo to Castellanza, and the following connections are possible:

Line A supplying Lomazzo and line B (by means of C) Castellanza; line A supplying Lomazzo and Castellanza; line B supplying Lomazzo and Castellanza; line A supplying Lomazzo or Castellanza; line B supplying Lomazzo or Castellanza, and line C supplying Lomazzo.

In the last case the power is supplied by the central steam station of the Società Lombarda at Castellanza, which constitutes the reserve for the hydraulic installations already existing at Turbigo and Vizzola and even for that of Brusio. The last combination can be arranged so that there can be a supply at 40,000 volts, in case of serious interruption, by means of high-tension transformers. Or the supply can be had directly at 11,000 volts from the generators at Castellanza by means of two hydraulic installations.

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A Striking Showcard which in Colours forcibly directs attention to the Merits of the Osram Lamp as made by the General Electric Company, Ltd.

THE WORLD'S PROGRESS IN ELECTRICAL AND GENERAL ENGINEERING.

Producer Gas Engines.

WHILST it is practically established that the small gas engine is rapidly giving way before the electric motor in those districts where a public electric supply is available, it is also equally true that the gas engine makers are finding full compensation in catering for the power requirements of innumerable isolated buildings and workshops. There is an important difference in the old and new sphere of the gas engine in that the large majority of the gas engines put down in future will operate on producer gas instead of on town lighting gas. For successful operation with producer gas the engines require to be modified in certain details, and there is still a good deal of controversy as to the modifications in design and running conditions which are necessary. Mr. H. F. Smith recently read a paper before a Canadian society in which he summarises the results of a very extensive personal experience with producer gas engine plants.

As to the degree of compression which is advisable with producer gas, he said that the best results are obtained with pressures of about 160lb. to 170lb. absolute. Higher compressions up to 200lb. or more are practicable, but tests have shown that the heat losses and increased friction more than counterbalance any increase obtained in the efficiency of the cycle. On the other hand, engines are working with compressions as low as 50lb. to 30lb.

An important point to be observed in connection with the high compression engines is that the combustion spaces have uniform and continuous walls. The engines for use on producer gas should not have any small openings out of the combustion chamber that are not closed flush with the internal surface of the inner wall. Relief cocks and air starter connections, as well as taps for indicator connections, priming cocks, &c., should be fitted with plugs or valves closing down flush with the internal surface of the combustion space. Failure to give careful attention to this feature will invariably result in premature ignition and back-firing.

Ignition devices suitable for use on petrol engines or with town's gas supply are frequently entirely unsuited to producer gas. Electric ignition should be utilised exclusively, and preferably a thoroughly substantial form of make-and-break igniter, either mechanically or electrically operated. Electrically operated igniters of this kind, however, should be supplied from a source giving not less than 40 volts and capable of supplying from 2amp. to 5amp. For mechanically operated make-and-break igniters a smaller current will suffice. Ordinarily, a storage battery of 10 to 12 volts and having a fairly low internal resistance will give satisfactory results. Dry batteries and primary batteries of any ordinary type are not well adapted to this service; storage batteries for ignition purposes and small dynamos for charging them have been worked out to a degree of perfection that makes the use of any other form of current supply a needless experiment.

Producer gas lends itself to several different methods of governing, and is perhaps the most tractable of all fuels in this particular. It is quite possible to make use of the ordinary hit-and-miss method of governing for producer gas, but this is usually not very satisfactory either as to regulation or as to its effect on the operation of the producer equipment. It is best to use some form of throttling control by which an impulse is secured at regular intervals. The most common method is that of straight throttling, with constant quality of mixture. Only one precaution needs to be observed in applying this method of control to producer gas, namely, that the mechanism whereby the throttling is brought about should be of the simplest and most direct possible construction. By all means the best method of throttling regulation, for producer gas, is that of varying the lift of the inlet valve. This system is ideal in that it does not introduce in the gas passages a single additional working part, the throttling being effected by the inlet valve itself.

Regulation by throttling the entire mixture at the point of admission to the intake manifold on multiple-cylinder engines has been satisfactorily worked out in a number of commercial designs, and will give good results when care is taken to provide simple and easy means for dismantling the governor valve so that it can be readily cleaned.

Governing by varying the quality of the explosive mixture, by using constant compression, can also be applied satisfactorily with producer gas, largely because of the extremely wide variations of mixture that are permissible with this fuel; the range over which producer gas mixtures are explosive is considerably wider than for any other fuel used in internal combustion engines, so that this fuel lends itself particularly well to this method of governing.

The proper control of the proportion of air to gas, where the method of governing by constant quality of mixture is employed, is of great importance. It is particularly important in multiple-cylinder engines that the quality of the mixture in the several cylinders be controlled at one point, and that by the single movement of one lever or valve. Furthermore, it is very important that this lever or valve should have attached to it an indicating device, showing at a glance the amount of air opening existing at each position. When an engine is to operate on gas from a suction producer, there is a tendency on the part of the makers to neglect the necessary provision for adjusting the air intake so as to cause the correct amount of suction on the gas line for the operation of the producer; it is customary to run the engine with the gas valves wide open, and control the mixture by closing down to a greater or less extent on the air intakes. A very satisfactory plan to control the mixture for an engine provided with an intake manifold consists of inserting in both the gas and the air passages ordinary plug cocks graduated to show the amount of opening.

The most practical sort of mixing device consists of an ordinary pipe tee, the branch of which is connected to the intake of the engine, one end connected to the gas main and the other end to the air-intake pipe, both gas main and air-intake pipe being fitted with graduated plugged cocks.

The location and size of the valves are of very great importance. The velocity of gas travel through the ports, for both inlet and exhaust gases, should not much exceed 80ft. per second, and a lower speed will give much more satisfactory results. Assuming the customary piston speed of 700ft. per minute, we might arbitrarily establish the clear internal diameters of the inlet and exhaust valves at approximately 0.45 of the cylinder-bore diameter. This may appear abnormally large, and many successful producer gas engines are fitted with smaller valves, but valves very much smaller, either inlet or exhaust, will undoubtedly be a more or less serious handicap to the successful operation of the engine. The cages and passageways leading to the valve proper should also be of ample dimensions.

The position of the valves necessarily varies with the type of engine. With horizontal engines, the almost universal custom is to place the exhaust valve and the inlet valve both on the vertical axis of the cylinder, the exhaust valve being below and the inlet valve above. With vertical engines there is little question but that, from a theoretical standpoint at least, both valves should be placed to open vertically downward in the cylinder head, in order that there shall not be any side pockets or any other notable irregularity of the contour in the combustion chamber.

To engineers accustomed to working with city gas, the size of gas main specified for producer work frequently seems unnecessarily large. It must be borne in mind, however, that the volume of gas to be handled is very much greater, and the question of pipe friction, and particularly the resistance to the gas flow introduced by short bends, must be carefully considered. It is, therefore, always best to install a pipe line from the producer to a point very close to the engine of the full size of the outlet connection provided on the producer equipment, regardless of what the dimension of the gas intake of the engine may be.

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Engineering Trade in the Argentine.

A CORRESPONDENT of *The Railway Gazette* indicates very clearly where British manufacturers are more or less backward in fostering and developing their sales in connection with the Argentine railways and engineering work generally in South America. He indicates how very important it is that leading firms should have a representative on the spot, citing as a half truth, which needs a great deal of moderation, the opinion often expressed in this country—that agencies and publicity on the spot are unnecessary since everything for the South American railways is bought in London. When ordinary stores are required by a South American railway company an indent from them is usually sent by the storekeeper to headquarters in Buenos Ayres, whence it is forwarded to the London office, where tenders are invited. It will be seen, therefore, that the storekeeper has a good deal to do with the choice of material, and is a person of importance on South American railways as at home.

When it is a question of locomotives or wagons or coaches being ordered, the chief mechanical engineer not infrequently prepares the drawings and specifications and sends them home to the London office, where the consulting engineers ask tenders. Here again it rests very largely with the man on the spot to decide on the class of material, and even in some cases its maker. The tendency is for the chief mechanical engineer to specify more and more in detail what he wants, and for these matters to be finally decided to a much smaller extent than formerly outright in London. But of course the inspection is, and will probably always be, done by the engineers in England.

The point for manufacturers of new and special appliances to note is that it is nowadays as important to impress the storekeepers and engineers on the spot who have to use the material as it is those in London, who are now more concerned in seeing that the man on the spot gets what he wants. With the increasing size and importance of the South American railway systems it is only natural that the chief engineers and storekeepers should expect and obtain greater responsibility and a freer hand in ordering the materials they themselves have to make use of. With the Government officials of course it is entirely a question of impressing those on the spot, and the Railway Exhibition at Buenos Ayres will prove a unique opportunity for so doing.

But there is another development besides the mere growth of the railway companies tending to increase the importance of the man on the spot as the deciding factor in purchasing, and that is the increasing tendency of the South American railway companies to manufacture rolling stock and other things for themselves. Thus at Junin the Buenos Ayres and Pacific Company is erecting new shops which will be capable of building twenty-two passenger coaches at once. At Rosario, when the present construction is completed, the shops will not have a much smaller capacity. The new shops of the Central Cordoba will at a pinch supply practically all its needs in the way of rolling stock, while the great Government shops at Tafi Viejo have been laid out on a scale sufficient to meet their full needs for many years to come. Even the Buenos Ayres Great Southern, which hitherto has not gone in as much for manufacturing as some of the other lines, appears likely to extend its manufacturing.

The result of all this is that while fewer orders for complete wagons and coaches are to be expected in Europe, more orders for machine tools, wood-working machines, and parts of wagons and coaches and accessories are to be expected.

The railway workshops on the whole have a very fine assortment of machine tools, and although there is not at present a very large field for high-class machine tools, such as automatics, outside the railway workshops, these will need more and more of the latest types of good tools, while wood-working machinery will be needed not only there but in other directions in considerable quantities.

There is no place in Buenos Ayres where a really extensive show of British tools is made or carried in stock, although quite a number of American and German firms carry considerable tools in stock—and the ordinary buyer as often as not refuses to buy a tool he has not seen. There would appear to be an opening for a first-class machine tool making firm, willing to keep a good stock of machines. Better still would be a combination of three or four leading tool firms whose products, to some extent at least, differed from each other, as, for example, firms specialising in drills, planes, small lathes, and punches respectively. One of the leading firms of agents would probably be prepared to take up such an agency as this, and the combination would lessen the idle capital of each individual maker.

As regards the class of tool, it seems likely that there will be a larger opening for those machines which can be handled by half-skilled labour than for the full automatic or for the very simple tool.

The increasing number of motor-cars leads one to suppose that small lathes for motor repairs might find a sale.

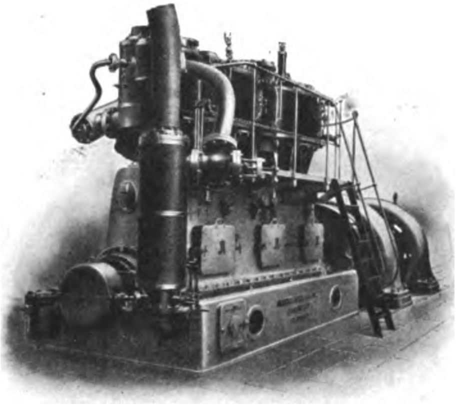
Of general machinery, air motors for pumping, small petrol engines or other oil engines, also barbed wire and corrugated iron, offer perhaps as extensive a field for a market as anything.

Electric appliances would not seem at present to have a very large field open outside the railways and workshops. In Buenos Ayres and the other great towns, for house lighting especially, a cheap material is usually used irrespective of quality, and the fact that the electricity supply business is in German hands has a great effect in settling the kind of stuff which is ordered. In the railway workshops the motors and switchgear are, of course, good enough except in the new Government shops at Tafi Viejo, where some extremely cheap Continental motors and switches were to be seen being unpacked. Better material had been specified, but the specification had been changed by someone. Where, as in many places, the railway workshops are being extended, there will be a large demand for small electric motors and switches.

◆

"Sentinel" Engines.

MESSRS. ALLEY & MACLELLAN have issued a new catalogue dealing with their well-known "Sentinel" engines. Recognised as typical of the best practice in high-speed engine work, these engines, which are of the double-acting, forced lubrication type, possess several unique



850 H.P. "SENTINEL" ENGINE DRIVING DYNAMOS.

features. The makers claim as particular merits the highest degrees of steam economy, efficient lubrication and governing, and, as regards material and workmanship, give a substantial guarantee against breakdown.

The two-crank compound engines are listed, as Class J, in eleven sizes of outputs of 45b.h.p. at 600r.p.m. up to 360b.h.p. at 375r.p.m. The triple-expansion, Class L, type is listed and priced in five sizes from 300b.h.p. at 475r.p.m. up to 750b.h.p. at 335r.p.m.

Separate valves are fitted to sizes of 100 h.p. and upwards, giving short direct ports and closer adjustment. Valve liners are fitted on most of the sizes, and the ports are cut from the solid casting, giving better steam edges. These points in design make for excellent steam consumptions, which, the makers state, are much in advance of consumptions obtainable with large sizes of central valve engines, the latter having the serious disadvantages of crooked ports, large cylinder clearances, and heavy leakage loss past the high-pressure valve.

All bearings are lubricated under pressure. For lubricating the cylinders on the larger sizes a "Sentinel" positive sight feed lubricator is provided, driven off the crank shaft. This is entirely automatic; feeds regularly; is independent of viscosity changes in the oil; and, after initial adjustment, requires no attention whatever other than the refilling of the oil container.

On all sizes the governor is lubricated under pressure, reducing the wear to a minimum. There is no need for the governor cover to be constantly removed for oiling by hand, and, since the lubrication is automatic and constant, the governor is very sensitive and accurate, and rarely requires adjustment.

◆

Alcohol from Wood Refuse.

A FACTORY is now in operation in the United States turning out on a commercial scale alcohol fuel prepared from wood refuse. The Ewen-Tomlinson process is employed. This consists essentially of treating the raw material, sawdust and other finely-divided timber refuse, under steam pressure and in the presence of acid in a large revolving drum. The result is that part of the wood is converted into glucose, which is washed off and carried to large tanks for fermentation. The final product is obtained in the usual manner in large stills and by subsequent rectification. The spirit produced is 190deg. proof ethyl alcohol, is said to be purer than grain spirit, and is manufactured at about one-fifth the cost.

It is said that the alcohol manufactured at these works costs about 3½d. per gallon, and thus provides the cheapest of liquid fuel of high calorific value. It is likely to become a serious competitor of paraffin and petrol for power purposes, particularly for isolated plants and motor-car service. Another large field for the supply is in the manufacture of oils and varnishes.

Other great advantages are to be gained by the introduction of this valuable process. Wood refuse will become too valuable to burn direct under boilers; the immense quantities of grain now used for the production of commercial alcohol will be conserved for food and fodder, and alcohol being available at lower prices for commercial purposes, will be more widely used, with advantage, in many trades where its present high prices have hitherto been a restriction. It is interesting to note also that after the wood refuse has been treated and the glucose extracted there still remains a marketable commodity which is worked up into briquettes and forms a high-grade fuel.

◆

Trade Catalogue Standardisation.

A NUMBER of engineers have combined to form a society under the name of The Engineers' Standardised Publications Association, which has as its object the development of a scheme for introducing uniformity in the style and subdivision of engineering firms' catalogues. It is very true that one of the troubles of the business man is to keep track of engineers' specialities, and it is practically an impossibility to keep a systematic record or file of price lists and catalogues as issued to-day in all sizes, sections, subdivisions, &c. The idea of the Association is to invite engineers and manufacturers to become members, and to introduce rules whereby the catalogue work of the manufacturers shall be as far as possible standardised. Such uniformity would undoubtedly be of great benefit to the buyer, and would also make for economy in the publication departments of the manufacturers; but we are afraid that the new Association has set itself no easy task. A great deal of the value of a particular catalogue depends upon its distinctive appearance and arrangement, and in this there is, and will continue to be, keen competition between rival firms. A promising feature of the work of the Association is that which has to do with the circulation of catalogues; it will be able to economise and secure the best publicity results by ensuring that publications are only supplied where they are needed for business purposes. The address of the Association is Craven House, Kingsway, London, W.C.; the secretary is Mr. J. D. Barton Inness; Mr. J. T. Hall is the technical manager, and the advisory committee includes Messrs. A. H. Dykes. T. W. How, H. M. Sayers, and W. H. Booth.

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Stored Coal and Self-Ignition.

WHEREVER coal is stored in large quantities self-ignition, or at least overheating, are always possibilities, and as such should be particularly guarded against. Cases of this nature are so frequent, and often so widespread and costly in their results, that it is evident the subject does not receive in all quarters that attention which is certainly its due. It would be too sweeping an assertion to say that bunker fires are always preventable, but there is no doubt whatever that the large majority of those which occur are due primarily either to carelessness or to ignorance of the causes from which overheating arises.

Oxidisation of the coal is the root of the difficulty, and its origin may be moisture, heat, or the two combined. The effect is slow, and in a deep pile may proceed for a long time unnoticed; but once overheating has taken a firm hold it is difficult to check, since, as the temperature increases, oxidisation also increases, and the effect of each is to accentuate the other and the evil generally. The coals most subject to heating are those of the bituminous class, and the more sulphur or moisture they contain the greater is the risk of combustion. It is, unfortunately, not always possible to keep moisture out, as, however dry coal may be delivered, the transfer to the bunkers on a wet day, for instance, may be quite sufficient to sow seeds of trouble.

In such a case the only precaution to take is to heap the coal as little as possible, since it has a better chance of drying when spread out, and if ignition should occur it will be easier to check. Ten or twelve feet is the maximum to which coal should be heaped, and if really efficient ventilation be provided at the bottom and around the sides, there will be less risk of ignition, as much of the heat generated will be carried off. The principles upon which such ventilation should be arranged do not seem to be at all well understood. It is common practice to place iron tubes open at one end to the air indiscriminately in different parts of the heap, the assumption being that they will suffice to carry off the heat evolved in the centre of the pile. A moment's consideration should show, however, that such an arrangement is inherently wrong in principle, since it does not provide the necessary draught. The only purpose these pipes will serve is to conduct air to the overheated mass, and the supply of oxygen thus obtained will accelerate combustion and increase instead of decrease the temperature. If ventilation be attempted it should be carried out in a thorough and scientific manner by means of ample ducts arranged upon a system that will produce a draught through the heap.

It should hardly be necessary to emphasise that a cool storage place should be chosen, and not one in close proximity to hot flue or boiler brickwork. The mistaken idea that such warmth will dry out any moisture that may be present has often led to overheating, and upon some occasions to serious fires. Instead of drying out the heap the warmth thus communicated simply assists oxidisation, and makes matters worse. In electric power stations, where it is a common practice to store coal in bunkers situated over the boilers, cases of self-ignition are very prevalent, and there is no doubt that the heat transferred from the boilers through the floor to the coal is the chief cause.

The frequency of bunker fires would certainly be less if the stored coal were watched more closely for heating than is usually the case. In the early stages there are no external symptoms to go by; one must penetrate to the centre of the heap, and indeed to all parts of it, if a proper check is to be kept. A very simple and effective means to this end is to ram sticks or iron rods into the pile in several places, withdrawing them occasionally to see if they are at all warm. A hand test should be sufficient, but in cases of doubt a thermometer may be bound to the rod with a piece of waste or cloth, and a reading taken after a few minutes. If the temperature approaches 140deg. F. the pile is too hot, and efforts should be at once made to root out the trouble. Turning over is, perhaps, the best remedy, but it is apt to be an expensive one, and is not always practicable. The usual alternative is to pour large quantities of water on to the heap for the purpose of quenching the fire, but this is often quite ineffective, as the water does not percolate to the centre if the coal is very small or the pile of any depth. To meet such cases the best remedy is to take a good-sized iron pipe and drill a number of holes through it at the end. This should then be rammed into the heap at the place where, by means of the rods, it is found to be hottest, and water at a high pressure turned on at the upper end. By this means only is it possible to get at the root of the trouble, and where turning over is out of the question it is to be recommended.

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Ozone in Ventilation.

THE effective ventilation of public buildings is a subject perpetually exercising the ingenuity of engineers and architects. The difficulty of securing a constant supply of clean and pure air of the right degrees of humidity and temperature, without causing draughts, is still as great a problem as ever in connection with large halls and the great blocks of offices and palatial new buildings now in vogue. The public library at Chicago has had improvements effected in its ventilation system which merit the serious attention of ventilating engineers in this country. The foul air in the library main reading-room has been the source of much adverse comment and discussion for years, perhaps no public building in the city having been subjected to so much condemnation of its ventilating system. An electric ozone generator has been installed to remedy these conditions. Ten thousand cubic feet of air per minute are required to be treated so that the ozone may be detected in the most remote part of each room having leaders from the main air duct. Tests have shown that the ozonizer installed is of great use in that it accomplishes the following results: The complete deodorising of the main reading-room, freeing the air from the obnoxious odour which for years has permeated the oft-handled papers, books, furnishings, &c., in the large room; the injecting of fresh sterilised air in the room at all times and the reduction of the humidity in the various rooms during the hot and oppressive days of summer; the disinfecting of all books, periodicals, &c., on shelves, racks, and tables; perfect comfort where formerly it was unendurable most of the time on account of lack of pure air and the presence of offensive odours.

The air ducts of the ventilating system being so complex in the library building, only the north portion of the building was available for demonstration with the ozoniser. The ozone generator installed in this large air duct, which measures 6ft. by 9ft., consumes about 715 watts in treating 15,000 cubic feet of air per hour. The generator is about 6ft. high, 11in. thick, and 1ft. wide. It is neatly encased and inserted in the opening of the duct to permit the air for the ventilators to pass through it, and thereby charging the fresh air supply with ozone. By placing the ozone generator between the fan and spray of water used in washing the air, greater efficiency was obtained than by placing it in front of the spray. A connection with the 110-volt service is made to a transformer which steps up to 7000 volts and supplies a series of electrodes in the form of ordinary hair brushes; a static electrical charge is thus maintained, which plays against a series of glass plates. Through this blue electrical discharge at 7000 volts air is forced, producing ozone. When the electrodes become dirty or clogged, they are easily rubbed together and cleaned as one would clean two hair brushes; placed back in position, they are then as good as new. The apparatus as installed is made in five regular sizes, the consumption of electrical energy varying from 25 watts for 25 cubic feet of air per hour to 660 watts for 10,000 cubic feet.

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Electric Motor-car Costs.

SOME valuable figures relating to the electric vehicle service of the New York Edison Company were included in a paper read by Mr. H. T. Cameron before the Electric Vehicle and Central Station Association, in New York.

This electric supply company began in 1901 with two electric vehicles, and it now has 65 machines in service. Each operator has a day card on which are inscribed details of the runs, stops, and mileage. A number of different forms are used in order to enable the company to keep a close record of the vehicles. Tyre mileage is kept by a brass tag, numbered, on each wheel, the tag being destroyed after its record has been taken. Each machine is given a thorough yearly overhauling, and all but one are constantly in shape for service.

In general the machines are equipped with from 40 to 44 Exide cells. The company has ten surreys, two landaulets, and one roadster for the use of the officials. These make 40 miles per day on one charge.

The life of the positive plates of the batteries is 368 days, and the service 9382 miles; the negative plates last 535 days, running 11,831 miles. There are ten lamp wagons for incandescent lamp and emergency service, running 30 miles per day on one charge. The life of the positive plates on these vehicles is about 364 days, with a record of 8188 miles, and of the negatives 558 days, or 11,064 miles.

Twenty-three general delivery wagons are owned by the company, and these run 35 miles per day on one charge. The haulage capacity of each is 2000lb. The positive plates have a life of 390 days and 8635 miles, while the negatives last 670 days and run 11,814 miles.

Other vehicles for heavy service are three trucks of from 2.5-ton to 3-ton haulage capacity each, used in hanging signs and arc lamps. These run from 20 to 25 miles per day on a charge, and the positive plates last 388 days, or 5612 miles, and the negatives 445 days, or 5919 miles.

The electric motor-car equipment is completed by five 5-ton cable trucks, running 15 miles per day each on one charge. These have 48 cells each, and the positive plates show a life of 395 days on a service of 3733 miles, and the negatives last 461 days on 9630 miles running.

In a short discussion which followed the paper, it was stated that at least 25 per cent. of the cost of the former horse-drawn service had been saved by the electric vehicles, and if all were modern in design the saving would probably be 50 per cent. An approximate tyre life on the older vehicles is about 10,000 miles. These are 3.5in. tyres, 36in. in diameter. The point was brought out that ton-mileage should not be considered in trucks which are largely occupied in such work as cable pulling, pole setting, and other construction duties. The maintenance of the cars is handled by a superintendent, a foreman of drivers, a clerk, one mechanic, one electrician, one blacksmith, one carpenter, one painter, two washers, one battery-room foreman, one battery man, one night man, and two helpers. The company assembles its own batteries, an hydraulic lift enabling them to change a battery in twelve minutes.

* * *

Large Electric Blower.

THE Thomas process for the manufacture of malleable and rollable cast-iron requires for its operation large quantities of air at comparatively high pressures. The stopping of the air current, even for an instant, means danger of burning out the converter bottom, and for this reason it has been customary to employ steam engines of a particularly reliable type for driving the blowers. An electrically-driven blower has been installed recently by the A. G. Peiner Rolling Mill in Germany for this service. Polyphase current at 10,000 volts is obtained from a distant power station and transformed into direct current of 520 volts. The direct-current sides of the rotary converters work in parallel with two storage batteries having a capacity of 2000 and 4000 amperes for one hour respectively. The batteries serve for compensating load variations caused by the motors driving the rolling mill and also as a momentary reserve in the event of failure of the current supply from the transmission line.

The twin-blower is capable of delivering 800 cubic metres of air per minute at a pressure of about two atmospheres when running at a speed of eighty revolutions a minute. As a regulation of forty to eighty revolutions per minute in shunt was required for the machine, the Felten and Guilleaume-Lahmeyer Works built a shunt motor with reversing poles for 500 volts with a permanent load capacity of 2000 horse-power. Another condition was that the degree of variation in the air supply should not be more than 1 in 30 at fifty revolutions per minute. This required a great rotating momentum, which was provided by making the armature of large diameter, and the necessity of a special flywheel was thus avoided. In order to carry out this construction of a so-called flywheel machine a considerable number of poles and a magnet frame of large diameter were necessary. The outside diameter of this frame is 6300 millimetres, and the machine is probably one of the largest direct-current motors ever built.

A 500,000-Volt Transformer.

PARTICULARS have appeared recently in German contemporaries of a testing transformer constructed by the A. E. G. for 500,000 volts alternating current. The core is rectangular, and on each of the two legs is a low-tension winding, each coil being arranged for 1040 volts. The two coils can be connected either in series or in parallel so that the ratio can be altered from 1040 : 500,000 volts to 2080 : 500,000 volts.

The high-tension coils are wound concentrically outside the low-tension windings; between the windings are a number of cylinders of insulating material. Each layer of the high-tension winding consists of 377 turns, so that the voltage per layer is about 9000 volts, and the difference of pressure between adjacent turns is about 24 volts. Special care has been taken with the arrangement of the high-tension terminals, the ends of the winding being completely immersed in oil up to the point where they enter the terminal insulators which lead out of the top of the transformer case. The insulators are made of wood and press-span, and are 8ft. 6in. long over all and are provided with deep corrugations. The total weight of the transformer when filled with 8000kg. of oil is 13,000kg., the dimensions are 6ft. 3in. by 10ft. by 8ft. 2½in. high, exclusive of the terminals, and the capacity is equal to 50k.v.a. at 500,000 volts. An arc was maintained on the secondary side of this transformer between two needle points in a horizontal plane 4ft. 3in. apart.

Electrification of Main Line Railways in France.

AN important scheme is being completed for the electrification of the southern lines of France. The first portion to be converted will be the line from Toulouse to Bayonne, about 400 kilometres, including the branch lines leading into the Pyrenees.

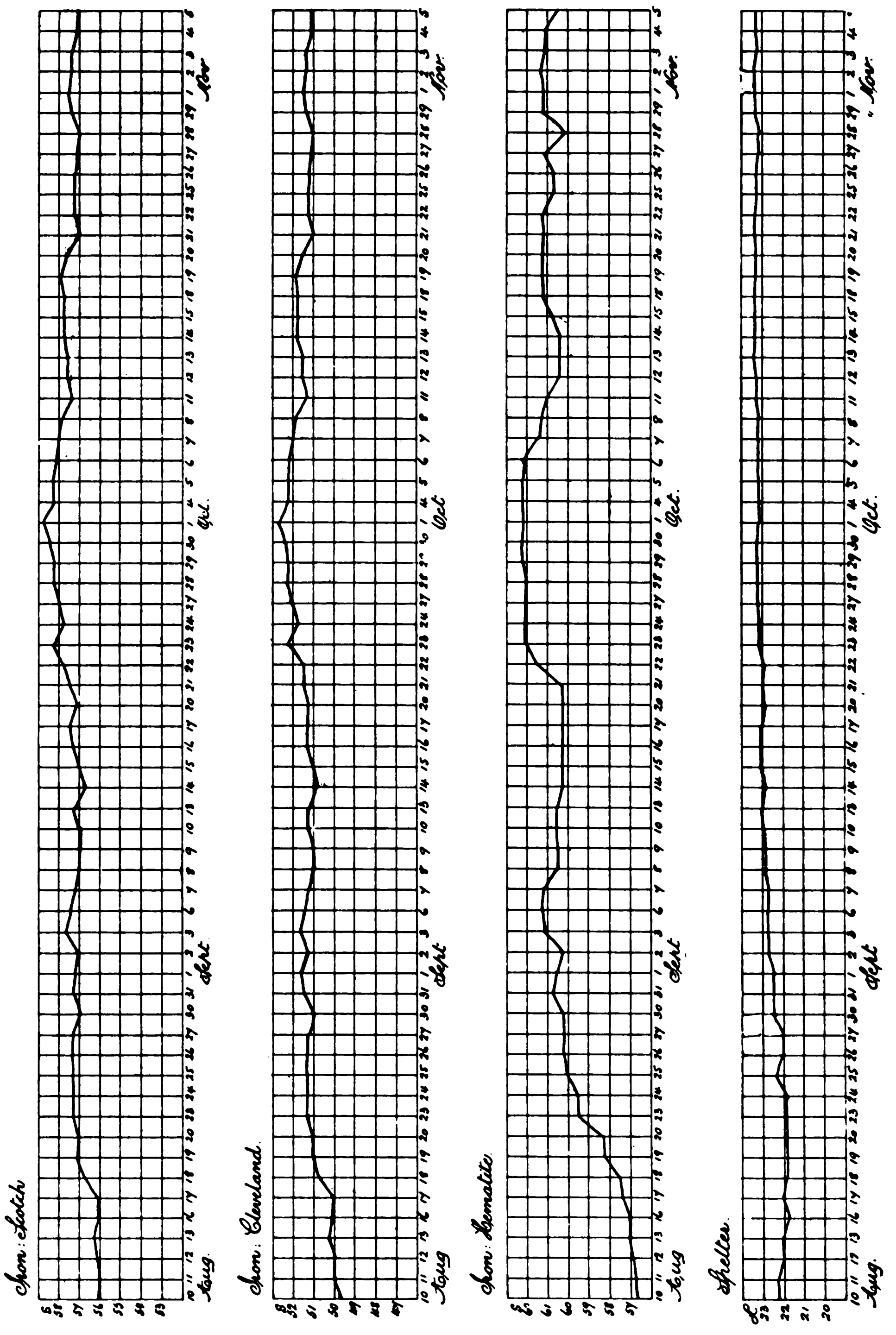
The initial power generating and transmission system to be put down has been decided upon and the work put in hand. The system will be single-phase alternating current, which will be supplied by two power stations, each of 30,000h.p. capacity. The one station will be at Soulom, near Lourdes, in the valley of the Gave de Pau, and the other is to be at Egat. Five substations are arranged for at the commencement, at Pau, Lourdes, Tarbes, Launemezan, and Montréjean; these will step the pressure down from 60,000 volts to 12,000 volts for the railway conductors.

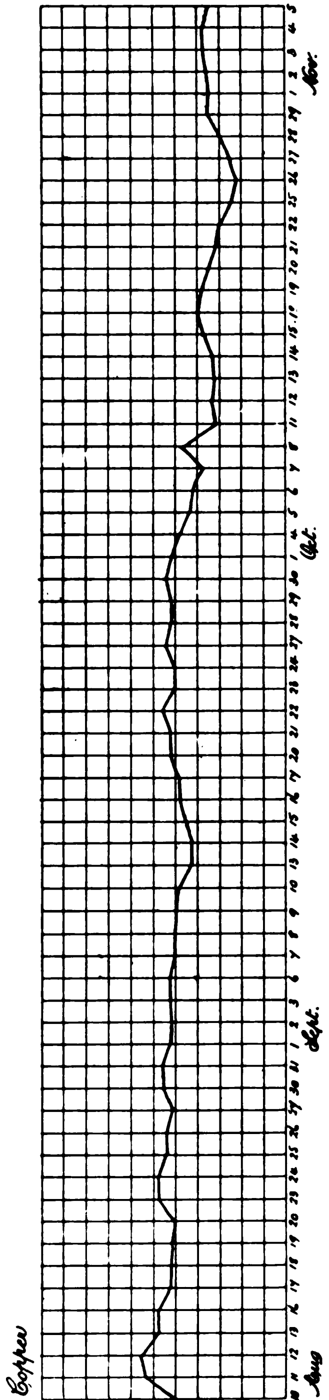
The first section of line will probably be ready early in 1912, and the other sections will be completed one after the other, so that it is hoped that in six years' time the whole of the 400 kilometres will be electrified. Locomotives of 1200h.p. and motor coaches of 400h.p. are to be provided. The type of locomotive will be selected from trial engines to be supplied by six different firms.

A mountain railway running from Arles viâ Teck to Pratz de Mollo (Pyrenees), close to the frontier, is nearing completion. It is 27 kilometres long, and will be supplied with current at 6000 volts single phase alternating. The company running this is affiliated to the Chemins de fer du Midi de la France.

Finally there is the line from Villefranche to Bourg-Madame—55 kilometres long—which rises to a height of 1631 metres at the pass Col de la Perche. This line is practically finished, and is worked on the third-rail system at 850 volts continuous current. The power is supplied at 20,000 volts by the hydro-electric station at Fontpedrouse.

Home Market Metal Prices for the Past Three Months.

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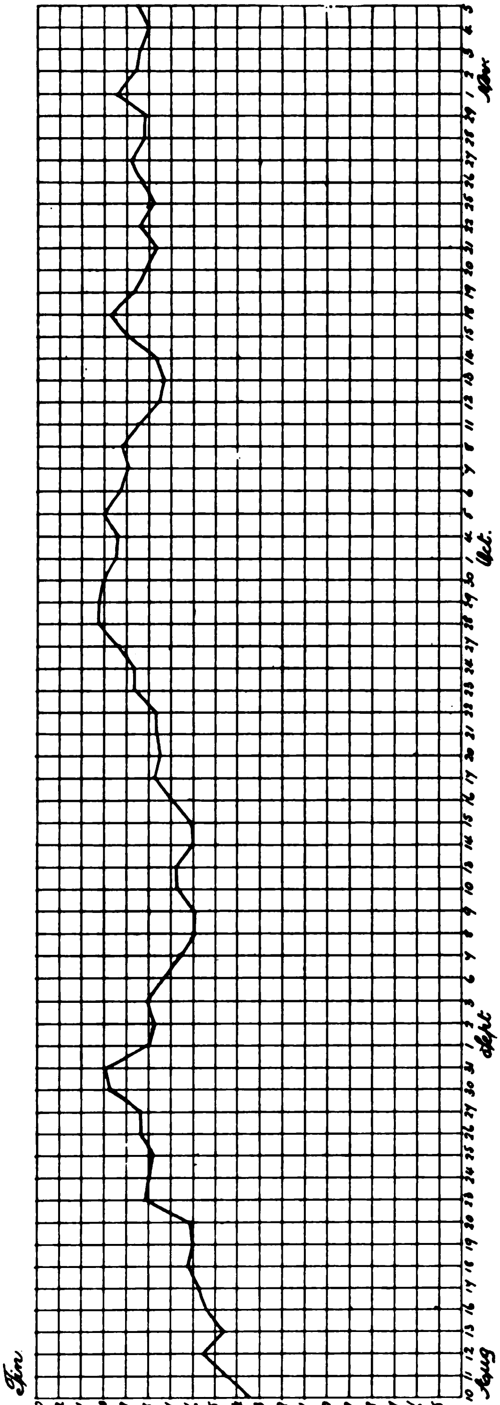
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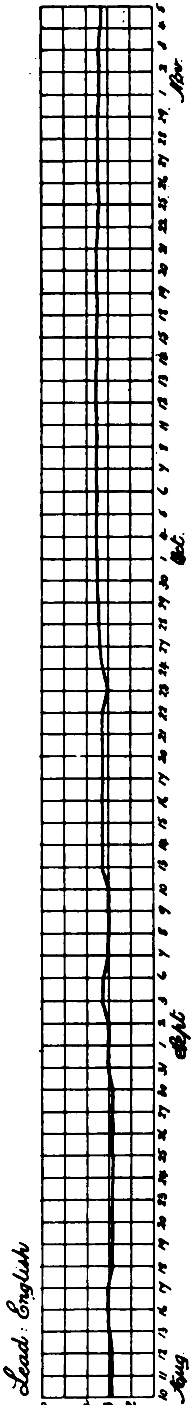
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Siemens' New Showrooms and Stores.

The ever-increasing business which Messrs. Siemens are doing in the way of electrical details, Tantalum lamps, fittings, and general stores, has led them to open entirely new premises for this class of trade. Previous to the public opening of the new branch we were kindly afforded an opportunity of inspecting the premises, which are in a very convenient central part of the city, being at 39, Upper Thames Street, E.C., and it is certain that they will be much resorted to by electrical contractors and private purchasers.

The interior of the building is arranged on well-organised lines, ensuring the speedy execution of orders over the counter. A system of lifts affords intercommunication between the six floors, the idea being that the purchaser shall not need to journey from one part of the building to another when he brings along a mixed order. Needless to say, the showrooms themselves are quite an exhibition of the most modern electrical fittings and appliances. The premises are wired on the Stannos system, which is well known as Messrs. Siemens speciality in this direction.

There can be little doubt that the new premises will prove to be very popular. Messrs. Siemens are British manufacturers of an extremely wide range of goods, varying from Tantalum lamps to motors of 16,000h.p. each, and from the finest bell wire up to submarine cables, consequently they are able to offer practically every electrical speciality which may be required, and to supply it at the right price.

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The Rhone Falls Power Scheme.

In our July issue we published an article describing the important proposal worked out by Professor Blondel and Messrs. Harlé and Mähl to utilise the waters of the Rhone by means of a barrage at Génissiat which would form an auxiliary reservoir, the main storage being ensured by the lake of Geneva.

A Commission, appointed by the Municipality of Paris and consisting of a number of eminent engineers, has been considering the proposals for some time, and they have now come to the following decisions. For a start, 24 turbines of 18,000h.p. each are to be installed; each of these will be coupled to a 12,000 volt, 25 periods, 3-phase alternator. The pressure is then to be stepped up ten times, *i.e.*, to 120,000 volts between phases for transmission. The capacity of the falls will be equal to an output of 360,000kw., and in round figures an annual output of 1,300,000,000kw. hours. To give an idea of the extent of these figures we would state that the total output of the works at Rheinfeldan for 1908 was 130½ million kw. hours, that is, one-tenth of the above figure.

As regards the probable date of completion, the Commission allows three years to complete the negotiations for the concession, two years for preparatory work, &c., and five years for construction, in all ten years. It is to be hoped that this estimate will be realised, but, to say the least, it is doubtful whether three years will suffice to complete the negotiations, especially as there will be great opposition on the part of those interested in the water-borne traffic of the Rhone. On this account there will be heavy expenditure in the construction of a suitable barge lift or locks. The Commission estimates a capital outlay (maximum) of £5,000,000, and it is satisfied that on this basis the business will yield about 9 per cent. when in full work; this yield will be increased as the demand for power increases until the full capacity of the falls is exploited.

The above figures are given by T. Koehn in an interesting article on some of the large European water power installations, published in the *Elektrotechnische Zeitschrift* The author in his preface gives the following tables, which are of considerable interest as indicating the probable industrial development of the eight countries mentioned :—

TABLE I.

Available water power in eight European countries based on a nine months' supply measured at the turbine shaft in horse power per second.

Name of Country.	Horse Power.
Great Britain	963,000
Germany	1,425,900
Switzerland	1,500,000
Italy	5,500,000
France	5,857,000
Austria-Hungary	6,460,000
Sweden	6,750,000
Norway	7,500,000

TABLE II.

Available power in horse power per second per square kilometre area.

Germany	2.6
Great Britain	3.06
Austria-Hungary	9.6
France	10.9
Sweden	15.0
Italy	19.0
Norway	20.0
Switzerland	36.6

TABLE III.

Available power in horse power per second per 1000 inhabitants.

Great Britain	23.1
Germany	24.5
Austria-Hungary	138.0
France	150.0
Italy	169.0
Switzerland	454.5
Sweden	1290.0
Norway	3409.0

Norway heads the list both as regards total power and power per 1000 inhabitants, while Switzerland has the greatest amount per unit area to its credit. At present, however, Norway's industry is so small that she can only use about 10 per cent. of her water power, while in Germany, for instance, it will not be very long before the whole of her available water power is made use of, and even then this would only satisfy about one-fifth of her present demand for power.

America, of course, throws the above figures into the shade. Niagara alone will supply more than England, Germany, and Switzerland put together.

* * *

Short-circuit Experiments on High-tension Main Line Railways.

An interesting series of experiments were recently completed on the experimental line at Oranienburg, which works with single-phase current at 6000 volts, 25 periods. The object of the experiments was to determine whether there would be any probable danger to life or of fire were a train brought into contact with a broken overhead wire under high pressure.

The trials lasted two days, and on both days the weather was fairly damp and there was a good deal of moisture in the atmosphere.

A short piece of cable was attached to the live overhead wire, and the loose end was dropped on to the roof of a passenger coach. The cable was placed on a number of different parts of the roof during the series of experiments. In almost every case as soon as the pressure was switched on a heavy short circuit took place. Sometimes it took a few seconds before the circuit-breaker at the station came out. The circuit-breaker was set to open at 800k.v.a. A water resistance was introduced, sufficient to prevent the circuit-breaker from acting, and it was then found that the material at the point of contact began to smoulder and then very soon burst into flame. In some cases the roof covering was found to be a sufficiently good insulator to prevent the passage of an appreciable current. In only one case, without the interposition of a water resistance, was a partial short-circuit created, in every other instance the circuit-breaker came into action. In this one case, therefore, the coach might have taken fire. If the cable was laid on the roof in such a way that the current passing was unimportant, it was only necessary to move the coach slightly to produce an immediate short-circuit. In most cases the current went to earth through the mountings of the gas lamps, which were connected to the under-frame by means of the gas pipes. The cable was then allowed to hang free, and the coach was slowly driven against it, and although the wire at first only came in contact with the woodwork, this was sufficiently wet to cause a short-circuit, at most after one or two seconds. In these cases the current was found to travel through the sheet-iron covering of the roof, from which it arced across various non-conducting portions to the ironwork leading to the under-frame. During the time that the cable was lying on the roof, without producing a short-circuit, the interior of the coach was tested for pressure to earth through a static voltmeter, and in no case was there a noticeable deflection of the instrument.

The results are regarded by the railway authorities as being highly satisfactory, the probability of any accident happening or damage being done before the circuit-breakers can act being looked upon as remote.

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Large Power Plant Order.

ONE of the largest orders ever placed for power generating machinery has recently passed to Messrs. Brown, Boveri & Co., and is of particular interest as forming the first half of the equipment of a huge works to be put down in Christiania for the electrical production of nitrate compounds from the atmosphere. The plant now ordered includes five three-phase alternators, each rated at 17,000k.v.a. (at 0.6 power factor) at 10,000-11,000 volts and 50 cycles, with direct-coupled exciters of 130kw., for direct coupling to water turbines of 14,000h.p. at 250r.p.m. It is said that the power station, of which this plant represents only half the capacity, will, when completed, be the largest in the world. Messrs. Brown, Boveri & Co., in referring to the extremely severe character of the work which this plant will have to undertake, mention that the order was obtained in competition with the leading firms of the Continent, and that it was settled upon the technical merits of the designs and not upon considerations of price, and, further, that the Brown, Boveri Company has no financial interest whatever in the undertaking. As indicating the immense size of the units, it is to be recorded that each alternator weighs about 200 tons and is some 20ft. in diameter.

⁂

Alldays Blowers.

THE catalogue, section F, recently issued by Messrs. Alldays and Onions, should be in the hands of all who have to do with smithy and foundry work. Dimensions, weights, prices, and duties of a complete range of the improved "Climax" roots blowers and exhausters, as for belt drive, or for direct coupling to steam engine or electric motor, are given with many illustrations and details of construction, erection, and performance.

The new list also includes particulars and illustrations of portable forges, smiths' hearths, "Empire" positive pressure blowers and accessories required for smithy and foundry equipments. Much useful technical information is given, and apart from its value as a descriptive price list the catalogue will be found of service as a reference book in this connection.

⁂

The Japan-British Exhibition, 1910.

WITH Prince Arthur of Connaught as Hon. President, the Duke of Norfolk as President, and some sixty of the leading spirits of commerce, science, and art acting as a general committee, the Japan-British Exhibition which is to prevail at the White City next year is assured of whole-hearted support so far as this country is concerned. As to the Japanese end of the scheme, this is sure to be taken up in the most complete manner, for the Government is fostering the venture. The idea of an Anglo-Japanese Exhibition in London is a very popular one with our allies, and all the departments of the Japanese Government—the Imperial household, war, navy, home affairs, finance, communications, education, agriculture and commerce, railways, &c.—are vieing with one another to make a notable display, and signs are not lacking that their sanguine hopes will be more than realised.

The Japanese section will be divided into eighteen groups, that is to say, those relating to (1) education, (2) fine arts, (3) liberal arts, (4) mechanical engineering, (5) electricity, (6) civil engineering and transportation, (7) agriculture, (8) horticulture, (9) forests, sport, fishing, &c., (10) alimentation, (11) mines and metallurgy, (12) decoration and furnishing, (13) textiles, (14) chemical industries, (15) various industries, (16) social economy, (17) colonisation, (18) armament, &c.

An extract from the printed circular issued in this country by the promoters over the signature of H.R.H. the Hon. President and the President is as follows:—

"In view of the alliance between Great Britain and Japan no conjunction could be happier. His Majesty the King, with characteristic solicitude for everything that makes for the extension of British trade and with keen appreciation of our allies in the Far East, sent to Prince Arthur of Connaught, the Chairman at the Inaugural Banquet of the Exhibition, the following message:—

"'I understand you will preside this evening at a dinner given in connection with the proposed Anglo-Japanese Exhibition next year. International exhibitions in these days largely depend on private support, and I hope therefore that the Japanese and British people will come forward to promote an undertaking which has for its object an increase in the commercial prosperity of both countries, and the uniting still closer of the bonds of fellowship which already exist between them.'

"His Imperial Majesty the Emperor of Japan. also sent a telegram as follows:—

"'I take advantage of the occasion to tender my congratulations to your Royal Highness and to those who join you in celebrating the inception of the "Anglo-Japanese Exhibition," and to express my sincere wishes for the complete success of the undertaking.'

"His Excellency the Japanese Ambassador on this occasion said that he felt confident that the Exhibition would confirm the friendly sentiments and would greatly help the commercial relations between the two countries, and spoke of the intense interest taken in the Exhibition by the people of Japan and of the large sum of money voted for it by the Imperial Diet.

"The Lord Mayor of London pledged his official and personal support, and expressed the conviction that nowhere would more real interest be taken in the Exhibition than in the ancient City of London. The full support of the London Chamber of Commerce and of the Associated Chambers of Commerce of the United Kingdom is also assured.

"The unique character of the Exhibition is sure to attract multitudes of people, not only from Japan and the United Kingdom, and the Colonies and Dependencies, but from every European country and from America, and cannot fail to increase the commerce of the two nations and to create new commercial channels between them and the rest of the world.

"It is hoped that the manufacturers and producers of this country, as well as those of the rest of the British Empire, will rise to the occasion by displaying the best of their respective productions in arts and industries, so as to make a representation worthy of this great opportunity.

"The Exhibition will have the advantage of the beautiful buildings, already known to millions of people, which made the White City so famous in connection with the

Franco-British Exhibition, and it only remains for the British Empire to provide a collection of exhibits which will worthily compare with those already promised by Japan, and to translate into reality the hope expressed by His Majesty the King that increased commercial prosperity and closer bonds of fellowship will result."

❧

Cowper-Coles Awards.

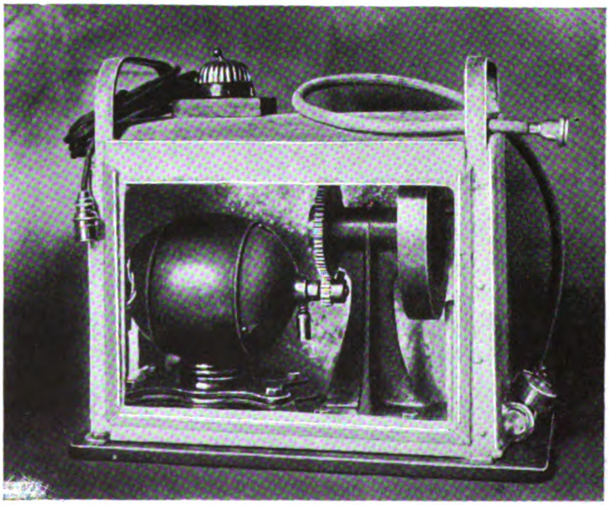
It is interesting to note that the exhibit of the Cowper-Coles Engineering Co., Ltd., at the recent Imperial International Exhibition, and of which we published some particulars in our issue of August last, has been awarded a Diploma for Grand Prize in connection with the metallurgical and electro-chemical exhibits. A further award of a Diploma for Gold Medal has been granted for their mechanical engineering exhibits, and also a Diploma of Honour for the work shown under the heading of Applied Chemistry.

New Long-distance Microphone.

A NEW microphone, invented by the Swedish engineers MM. Egner and Holström, is described in *L'Industrie Electrique.* This powerful instrument enabled them to speak from Stockholm to Paris with the greatest ease.

The principle on which this microphone is constructed lies in utilising that part of the membrane where the vibrations have their greatest amplitude—that is, of course, at the centre—and to transmit these vibrations to a disc situated just above the granular carbon. A small circular steel box, from which the air has been exhausted, is clamped to the centre of the membrane, and the underside of the box is in contact with a disc which rests on the granulations, the box being very nearly of the same diameter as the disc. The underside of the box vibrates at the same rate and with the same amplitude as the central portion of the membrane. The whole apparatus is made air-tight, and is filled with hydrogen.

❧



The "Whipall" electric tyre pump, introduced by E. E. Coy of Liverpool, is one of the essentially useful labour and time saving devices of the up-to-date garage. The principle and construction of this self-contained machine are evident from the illustration.

THE
ELECTRICAL MAGAZINE
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An Illustrated Magazine Devoted to the Electrical, Engineering, Shipbuilding, Iron and Steel, and Mining Trades.

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STEAM TURBINE POWER PLANT AT THE IMPERIAL WHARVES, WILHELMSHAVEN.

A MOST interesting and thoroughly up-to-date steam turbine electric power station has recently been installed at the Imperial wharves at Wilhelmshaven, the interior of which is shown in the accompanying illustration. The turbines and alternators, as well as the direct-current generators, were constructed at Baden, Switzerland, by Brown, Boveri & Company, and were installed under the direction of Mr. Emil Sinell, of Berlin. This central station has four steam turbine units, two of which operate three-phase alternators of 700kw. capacity with a maximum capacity of 875kw., the remaining two driving 350kw. generators and having a maximum output of 440kw. each.

The larger units supply a polyphase alternating current of 50 periods per second at a pressure of 1050 volts operating at a speed of 1500r.p.m. and the turbines developing a maximum of 1300 h.p. each. The smaller turbo-alternators also supply a three-phase current of the same voltage and frequency, the speed of the sets in these cases being 3000r.p.m. and the output of each turbine 660 h.p.

For exciting the fields of the larger alternators at full load the energy required is 8.85kw. and for the smaller alternators 4.25kw., the current for excitation being supplied by motor-generator sets, a part of one set being noted in the foreground in the illustration. The electric power utilised for each of the condensing sets is from 23kw. to 30kw. for the water-cooling pump. The temperature rise of the turbo-alternator No. 1 of 350kw. is for the stator 35.12deg. C. and for the rotor 38.1deg. C., while for the turbo-alternators No. 2 and No. 4, of 700kw. each, the stator rises of temperature are 37.2deg. C. and 36.4deg. C. respectively, while those of the rotors are 35.5deg. C. and 34.2deg. C. respectively.

The regulation of the steam turbines is said to be excellent, as a variation of load of 120kw., when suddenly thrown on, was found to vary the speed only .8 per cent., and when suddenly thrown off 1.6 per cent. for turbo-alternator No. 3. The variation in speed from no load to full load was found to be 1.7 per cent. for turbo-alternator No. 3, *i.e.*, the larger size, and 2.3 per cent. for the smaller units.

The steam consumption of these turbines also proved to be most satisfactory. The large units operating with dry steam at a speed of 1500r.p.m. were guaranteed to have a steam consumption at full load not to exceed 9.8kg. per kw.-hour, while the actual test showed the steam consumption to be 9.02kg. The test also showed a steam consumption of 9.3kg., 9.23kg., and 11.2kg. respectively for two-fifths load, three-fourths load, and one-third load, while the steam consumption guaranteed for these outputs respectively was 10.3kg., 10.7kg., and 13.7kg. The steam consumption for the smaller loads under the same conditions of dry steam without superheater was equally satisfactory, considering the size of the unit.

The turbo-alternator of 350kw. capacity tested out with steam consumptions under the above conditions at one-third, two-thirds, quarter, and full load, of 11.55kg., 10.6kg., 10.35kg., and 10.05kg. per kw.-hour respectively, while the guaranteed consumption in each case was considerably greater.

A very fine rate of steam consumption was obtained with both the 350kw. and 700kw. units where superheated steam was utilised at a temperature of 320deg. C. For the larger units the steam consumption per kw.-hour under measurement was found to be 7.16kg. for full load, while for four-fifths, two-thirds, and one-third loads the steam consumption was 7.4kg., 8.6kg., and 8.95kg. respectively; the guaranteed consumption being 12kg. per kw.-hour at one-third load, and by actual measurement it was found to be only 8.95kg.

The smaller unit with superheated steam at 320deg. C. has a steam consumption of 8.36kg. at full load and 10.3kg. at one-third load, while the guaranteed consumption for these outputs was 9.3kg. and 13.4kg. per kw.-hour respectively. It is claimed by the builders that if the larger dynamos had been constructed for an overload for an output of 1150kw. the steam consumption per kw.-hour would have been less than 7kg.

Some remarkable results were obtained by steam turbines of this type installed in a central station at Liége, Belgium, and tested by the engineer of the Society of Electricity

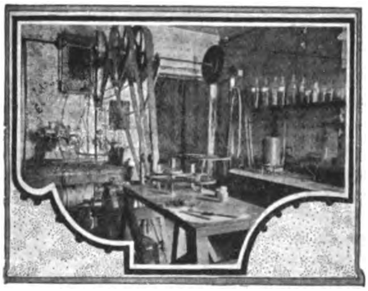
Turbo-Electric Plant of the Imperial Wharves, Wilhelmshaven.

and Tramways, Brussels. These Brown-Boveri-Parsons turbines each have a capacity of from 1500kw. to 1800kw., operating with a steam temperature of 300deg. C. superheat.

To each of these turbines are directly coupled two dynamos, one of which is a three-phase alternator of 1800kw. capacity and the other a direct-current generator of 850kw. capacity. With these units both the direct and the alternating current machine may be run on load by overloading the turbine, and practically the full capacity can be obtained from both generators

The results obtained by this engineer in the recent tests are of special interest. The steam consumption when the 1800kw. turbo-generator and alternator were supplying 1926.6kw. was 6.9kg. per kw.-hour, which is a most satisfactory result, the total steam consumption at this load being 13,427kg. per hour. This test was with cooling water at 9deg. temperature and the steam temperature 294deg., the steam pressure being 11.5kg.

With an output of 1427.5kw., the temperature of the cooling water being the same and the pressure of the steam 12.6kg., at a temperature of 298.7deg., the steam consumption per hour was found to be 10,410kg., or 7.3kg. per kw.-hour. At about half-load, or 1068.7kw., the steam consumption was 8250kg. per hour, the weight of the steam per kw.-hour being 7.685kg. with a superheat of 300deg. C., the steam pressure at this load being noted as 12.1kg. These tests, showing the steam consumption of 6.9kg. per hour at a trifle over full load, are undoubtedly most satisfactory, and show the high efficiencies obtained with steam turbines of 1500kw. to 1800kw. as constructed at the present time.



THE REVIVAL OF THE ENDLESS RAILWAY.

THE appearance of Messrs. Hornsby's chain track tractor calls to our remembrance the numerous predecessors on the same lines. Endless railways fitted to the wheels of traction engines have been the troublesome dream of many inventors. As an antiquated scheme it has few rivals, and still the subject is being revived in a ceaseless number of ways. The endless railway was taken up as long back as a hundred and thirty-eight years ago. Mr. L. R. Edgeworth, in his patent specification, says:—"The invention consisted in making portable railways to wheel carriages, so that chains of pieces of wood were connected to the carriages, which were moved in regular succession in such a manner that a sufficient length of railway was constantly at rest for the wheels to roll upon, and when the wheels had nearly approached the extremity of this part of the railway their motion laid down a fresh length of rail in front, the weight of which in its descent assisted in raising such part of the rail as the wheels had already passed over, and thus the pieces of wood which were taken up in the rear were in succession laid down in front, so as to furnish constantly a railway for the wheels to roll along." Mr. Edgeworth spent forty years in experimenting with his portable railway without being able to gain the necessary strength and lightness desired, yet he was satisfied that the scheme was feasible.*

In 1825 Sir George Cayley patented the application of a revolving or endless railway to wheel carriages. Two endless chains compassed round the fore and hind wheels on each side of the vehicle. In both of the above instances the steam engine was adopted as the motive power.

Omitting many other arrangements, we come down to the best plan for an endless railway—the one patented by Mr. James Boydell in 1854. A great number of traction engines were made by Messrs. Chas. Burrell & Son, of Thetford, between 1854 and 1863, all fitted with the Boydell endless track. These were sent to all parts of the world, and for a time worked very well, chiefly for handling heavy loads on soft ground not previously levelled. They were used for ploughing on the direct traction system. For travelling over boggy fields they did very well, making very little impression on soft land. Fig. 1 shows the rails fitted to the hind and fore wheels of a small traction engine. The wear and tear of the Boydell and other endless railways caused them to be relinquished. Many of the fine engines made by Messrs. Charles Burrell & Sons had the shoes removed, and afterwards fitted with ordinary wheels, and such engines worked for many years.

The system of endless railway patented

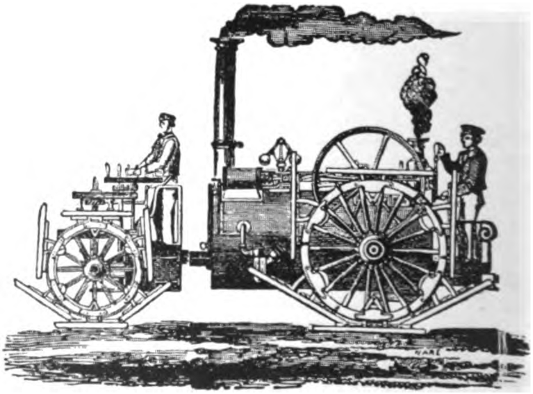


FIG. 1. THE BOYDELL ENDLESS RAILWAY FITTED TO A SMALL TRACTION ENGINE.

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* "The History and Development of Steam Locomotion on Common Roads," by W. Fletcher, 1891. E. and F. N. Spon.

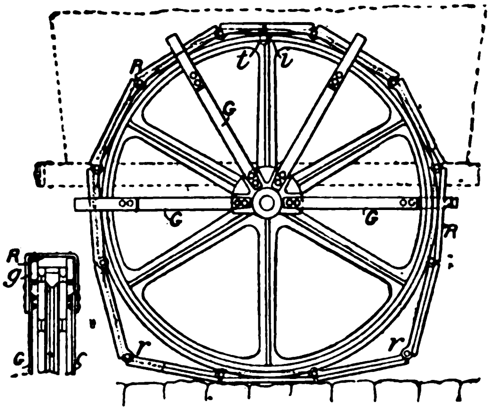

FIG. 2. THE CLARK ENDLESS TRACK.

by W. C. Cambridge in 1856 was similar to the Boydell. W. E. Newton's plan, patented in 1857, consisted of an endless track passing round hind and front pulleys under the wheels of the carriage. The steering of the tractor could be worked by simple means. A year afterwards J. Welch's plan was patented; this consisted of two chains of links passing over pulleys at the ends. The rails were driven by means of a rack and pinions. Wood blocks were secured to the chain to prevent slipping on the roads. A means of adjustment of the chains was also provided. The side elevation of this endless track presents a similar appearance to the Hornsby track illustrated at Fig. 4.

We pass over other plans to notice the arrangement patented by Messrs. Fowler & Burton, of Leeds. In road locomotives provided with an endless track the main axle is supported by a frame carrying three wheels. These wheels have double flanges, between which the endless rail, composed of a number of short rails, passes. Above the axle is fitted a guide pulley. The whole apparatus is driven by a sprocket wheel on the axle; two other sprocket wheels are driven by the chain of links. The above arrangement, patented in 1858 by the Leeds firm, is interesting. Mr. A. M. Clark, in 1874, patented the endless track, consisting of a chain of shoes joined together and placed round the driving wheels. Fig. 2 shows the side elevation of the wheels, and also the upper half of the track working between guides.

The Ingleton automatic track may be noticed, see Fig. 3. It was intended for ploughing engines used in South America. The inventor says:—"Large sums of money have been spent in making tracks that would carry engines of this class over soft land, but the great difficulty to be overcome in most of the devices was the turning of the engine." In this arrangement the track can be raised from the ground automatically with the steering of the engine, so that in making a sharp turn with the engine the track is thrown out of action, and the former is allowed to turn as easily as if the track were not there.

There are many other forms of endless-railway schemes, which have been patented, tried, and eventually discarded, but these we leave to deal with the latest and most striking form, made by Messrs. R. Hornsby & Sons, of Grantham. Some years ago

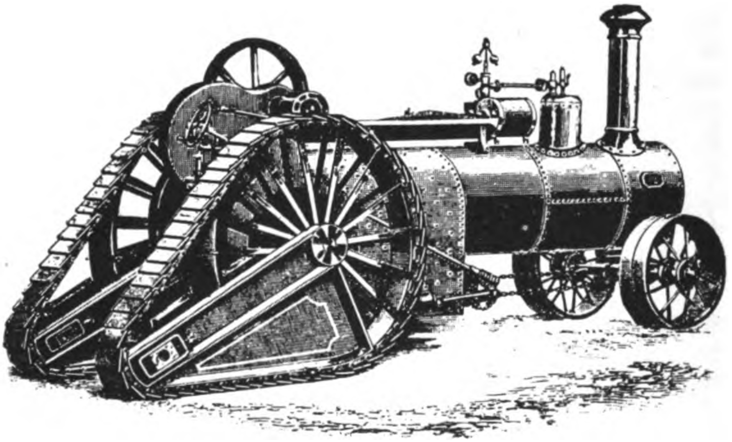

FIG. 3. THE INGLETON AUTOMATIC TRACK.

Messrs. Hornsby showed an oil traction engine at the meeting of the R.A.S.E., at which show the engine was awarded a silver medal. Later on another oil traction engine was made which gained the War Office prize. This latter engine was purchased by the War Office for experimental purposes. The driving and leading wheels of this engine were removed, and the engine was altered so that the chain track and gearing for working the same could be applied.

Many experiments have been made with this transformed engine, and the results of the trials have been briefly described in a number of non-technical journals and the daily Press. It was termed a 20 h.p. engine; the cylinder of the former engine was 13½in. in diameter, the stroke 16in. It hauled 20½ tons up a gradient of 1 in 20, and there were three speeds fitted. The War Office engine is on the same lines and of similar dimensions.

The patent for the tractor was taken out in July, 1904. Fig. 4 represents a side view of the tractor. This system provides essentially an endless chain that travels round the weight-carrying wheels, forming on the inside a track on which those wheels run. The chain track consists of a number of feet, linked together with intermediate locking links, which render the bottom portion of the chain rigid, so as to form an arc with a radius of about 19ft., the inside of which is used as a track for the weight-carrying wheels k^1, l^1, and m^1; these run on roller bearings and transmit the weight of the engine to the track. The rear wheel *c* is the driving sprocket; the upper part of the chain pulled over by the driving wheel moves forward and is guided by the front sprocket wheel to form a fresh and endless track. Steering is effected by the application of brakes upon the bevel wheels of the compensating gear. With this arrangement, by turning the hand wheel in one direction the brake is applied to, and retards the motion of, one of the bevel wheels of the compensating gear, and by turning the hand wheel in the opposite direction the brake is applied to the other bevel wheel of the differential gear, so that the vehicle can be steered as required. Each of the bearings of the front shaft *d* is made adjustable, to enable slackness of the chains which pass around the two pairs of rear and front sprocket wheels to be compensated for. As there are about forty pins in each chain, the smallest amount

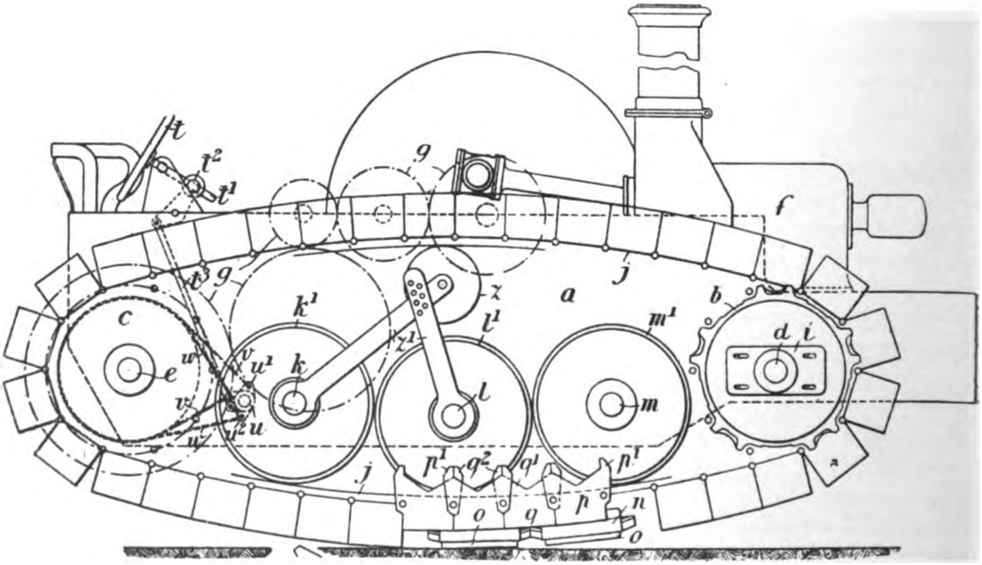

Fig. 4. The Hornsby Chain Track Tractor.

of wear of each will cause a large amount of adjustment to be needed to keep the chain tight. The wear and tear of eighty pins will cause a great expense in upkeep of the vehicle, and as the pins become worn the chains will not run silently, which is very desirable.

In 1906 another patent was taken out by Messrs. Hornsby for an improvement in the track, so as to render the same more durable and simple, more silent in running, and capable of having worn parts renewed with greater facility. A means of lubrication of the eighty hinge pins is also provided, but to lubricate each pin separately must be a tedious process. A year later, 1907, the steering of this ponderous engine was the subject of a further patent. It has been found that manual power is sometimes insufficient for steering. In this case compressed air, maintained in a reservoir by means of a pump on the engine, is distributed to a piston in a cylinder. The piston rod acts on a bell crank, which applies the band brakes for steering sufficiently powerfully on rough ground. In addition to the 20 h.p. paraffin tractor as mentioned above, a 35 h.p. petrol chassis has been fitted with the chain track. Trials have been carried out with both these machines, and some wonderful results have been obtained. The 35 h.p. chassis is fitted with four speeds: 1.8, 3.5, 5.5, and 8 miles an hour; it weighs 4 tons 1 cwt., and will haul 25 to 30 tons at a speed of four to five miles an hour on ordinary roads. Moreover, it will haul a lighter load over bush tracks, sandy or boggy ground, &c., where the ordinary type of tractor would be bogged. The 20 h.-p. chain tractor paraffin engine weighs about 15 tons, and is fitted with three speeds of 1$\frac{1}{2}$, 2, and 4 miles an hour. The present tractor, with its five axles and bearings, the four sprocket wheels, six rollers and two heavy chains, cannot weigh much less than 18 tons.* It is interesting to compare the 35 h.p. petrol tractor with a single cylinder traction engine; a steam traction engine of the ordinary type with a cylinder 8$\frac{1}{2}$in. in diameter and a 12in. stroke weighs 9$\frac{3}{4}$ tons, and will haul 25 tons on all kinds of roads at four or five miles an hour. A small engine of this size would easily develop 35 h.p. Could the chain tractor, with its load of chain, haul the same load? The patent specification says:—"It is well known that traction engines as now constructed are limited in their use by reason of their wheels sinking to too great an extent when travelling over soft or sandy ground and over surfaces of considerable irregularity." South America is mentioned as a country where swampy land prevails.

In the Argentine Republic, English straw-burning traction engines are used on swampy land, saturated with rain, where there are practically no roads; the wheels of these engines do not sink in to militate against their utility, because the wheels are properly made for the unfavourable conditions. Some hundreds of engines are employed in the Argentine; they drive heavy thrashing machines and haul the machines and other tackle over miles of roughly-ploughed land; these same engines are used for ploughing on the direct traction system.

With these examples before us it is hardly fair to say that ordinary traction engines are useless on desert or swampy land. For the Colonies we fear the track tractor will be too heavy for the weak bridges. It is said that this chain tractor will revolutionise transport. We have had many special traction engines in the past that were intended to do the same, such as the Boydell engine of 1860, the Thompson Road Steamer of 1870, the Pedrail of recent times, the ring tractor, and others. These have passed away; the traction engine is apparently the survival of the fittest; it remains. We trust that the Hornsby tractor will realise all expectations, and repay the makers for its cost of construction.

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* One of the daily papers recently said the Hornsby tractor weighed 30 tons and could be driven at a speed of 40 miles an hour. The weight may be correct, but the speed cannot be.

PUBLIC HEAT SUPPLY FROM CENTRAL STATIONS.

THERE are many indications that this country is about to take up the well-established American system of distributing exhaust steam by means of street mains for public heating service. High fuel costs, and the custom of building tenements, flats, and great office blocks are factors which have led the American to look upon the steam or hot-water radiator as his fireplace. It will be long ere the Englishman entirely overcomes his prejudice in favour of the cheery coal fire, but gas stoves and radiators are already firmly established, and it would seem to be only a matter of time and the appeal of a money-saving form of heating to make the exhaust steam method of heating as general in this country as in the States. Not only is the subject of public heat distribution being well considered by our electric supply authorities, but there is a great deal of attention being devoted to the design of combined self-contained lighting and heating plants for private installations. In this the general principle followed is the same as for central station systems—the electric current is generated by a steam-driven dynamo set, the engine of which exhausts into a calorifier, or hot-water heater, of some kind ; the dynamo works in conjunction with a storage battery for levelling the electric load, and the calorifier in conjunction with a suitable hot-water accumulator or storage tank. Details of such private installations will form the subject of a future article ; for the present it will be of interest and assistance to our central station authorities to quote a few facts from records of combined electricity and heat supply systems as published recently in a number of lectures and papers read before American engineering societies. Steam heat-transmission is coming into more and more prominence in the United States, but is still neglected in many localities where it would be found most profitable, and the electric supply authorities should instal a low-pressure steam-heating plant along the lines that have been so well tried during the last twenty years.

In the case of an old plant which, having reached its limit of efficiency, is yet unsatisfactory in comparison with modern equipment, the investment necessary for a district steam system would be lower than that necessary for a modern equipment, and the results obtained would compare favourably with, and probably exceed, those of a thoroughly modern plant without a district steam system. A steam-heating system has been found in many cases to pay for the entire coal bill of the plant, and to leave a substantial balance besides.

What is generally conceded to-day to be the best practice is a system the extent of which is such that the exhaust steam from the plant will meet the average demand in ordinary weather. Then in extreme weather live steam, in necessary quantities, may be added to help out the heat supply. The upkeep of the street steam mains is easy and inexpensive. No cheap installation can be expected to give good results, and the best material and construction known should be used. The work must all be done carefully and to grade, so that the whole system will drain its condensation to points where it may be readily trapped off. There must be no low spots without traps, where the condensation will accumulate. The bottom of the pipe-trench requires special attention and should consist of broken stone or coarse gravel, in which one or two drain pipes should be laid, so that the ground around the main may have a good drainage and be as dry as possible. In some installations an effort has been made to get a return of the trapped condensation to the plant, but the cost of this is prohibitive in anything but a small, very compact system centred closely around the plant. At the power house the exhaust steam should be passed through a separator before entering the mains, for the purpose of removing the water and oil that pass with it from the engines.

The usual season for the demand for steam is from the middle of September to the first or middle of June. Depending on the conditions, however, some companies find it profitable or desirable to keep steam on during the summer months. This will cost but little in non-condensing plants, and a neat business may be built up as well by being able to furnish a continuous supply of steam for hot-water tanks in hotels, restaurants, flat buildings, barbers' shops, laundries, &c.

House services are usually installed from the mains into the buildings at cost. The company also provides at cost the reducing valves, cooling or economy coil, and trap, which are necessary, except in those buildings piped on the "atmospheric" system, in which case economy coils are not needed. It is always best, particularly in meter installations, to get consumers to install a separator.

Flat rates should be avoided if possible, and if given at all should be on office buildings, where the maximum demand for heat is for only twelve hours. They are based on the total square feet of radiation connected or else on the cubical space heated. A flat-rate customer as a rule will practise no economy at all, and, when the house gets too hot, will invariably throw open doors and windows rather than take the trouble to turn off the steam. From 1s. 3d. per square foot for direct radiation, and from 1s. 8d. per square foot up for indirect radiation, per year is the usual flat-rate charge when based on radiation. This varies in different localities, due principally to the cost of coal.

On metered condensation the charge is made at so much per 1000lb. of steam condensed. The rates vary from 1s. 8d. to 3s. per 1000lb. either for all the condensation or for the first 10,000lb. A number of companies use a sliding-scale rate, the large consumer getting lower rates than the small.

The opinion of the various supply companies is in favour of the almost total use of the condensation meter. It tends to stop all waste, and consumers acquire the habit of turning off the steam instead of opening windows. They are more willing to cover bare pipes, and they take greater interest in and better care of their heating apparatus. The benefit of the meter is best illustrated by a plotted curve of steam consumption of a plant before and after meters are installed. There will be gradual peaks in the morning and evening, and some falling off at night, on the flat-rate chart. In comparison with this the same curve, with meters used, will show a marked decrease in total steam consumption with much more prominent peaks. There will be a sharp rise in the morning, as people turn on steam when they get up, to warm the house after it has cooled off during the night, and this will gradually fall off by ten o'clock, as the day gets warmer. It will gradually pick up again after three o'clock, when the sun goes down and the cold of the evening begins. From this peak it will fall off pretty rapidly as the steam is shut off before people retire for the night.

The condensation meter itself is very simple, it being designed on the principle of a balance. On each side of the balance is a receptacle or cup that holds just a given weight of water, according to the size of the meter. The condensation always flows into the cup that is up, and when it receives its full weight it overbalances, goes down and empties, the cup on the other side going up, and into it the condensation then flows. The balance is connected to a dial gearing, which registers the number of pounds discharged.

It is usually considered advisable for the company, apart from having clearly defined rules and regulations regarding piping, to go no farther than installing the service pipe, connecting it up, and installing the meter. Before the steam is turned in to the consumer's apparatus it is essential that the installation be carefully inspected. If the charge is on a flat rate, all piping should be covered, or else included in the total radiation on which the charge is based. If the charge is by meter, particular care should be taken to point out to the consumer all things which will tend to increase the steam consumption.

After a season or two of use the consumer will appreciate the many advantages of city steam. Some of the advantages frequently overlooked are as follow: (1) In a new house or building no boiler is required, and if a hot-water system had been considered, a saving of about forty per cent. in the amount of radiation necessary to install would be accomplished. (2) With no boiler, the danger of boiler explosion and trouble of boiler inspection disappear, and in some cases a lower rate of fire insurance is obtained. (3) Increased cleanliness about the house, cellar and grounds, as there is no coal and ash dust to blow about. (4) No repairing of boiler, or boiler to give out in the middle of winter, and any troubles the customer does have are assumed by the steam-heating company, which employs competent men to take care of them. (5) Steam is always there, day and night, and always ready for use when required, and an even temperature can be maintained at all times.

The successful and most economical operation of a power house using its exhaust steam for heating is a thing that has to be carefully worked out for each individual case, the point aimed at, of course, being to generate both steam and electricity as cheaply as possible. The demand of one must be balanced against the demand of the other, and a happy medium arrived at by operating only the equipment best suited to the conditions, with no aid or as little as possible from live steam.

An electric-light plant, also furnishing steam for heating purposes, was operating one winter day. Two engines were running which, by reason of the electric load, developed 200h.p., and this necessitated the use of a certain amount of live steam to keep the pressure on the steam mains constant. A third engine was started and a portion of the electric load transferred to its generator. Seemingly strange, the pressure at once increased on the steam mains, and one boiler could be shut down. This plant also demonstrates that they use more coal when their electric load is lightest and live steam has to be resorted to than they do when carrying the peak.

From experience gained during the last ten years in the heating business, it has been found that the back pressure is the most profitable load the engines carry. Ten years ago a man who attempted to operate a high-speed engine maintaining a back pressure of any amount in excess of five pounds would speedily have had his reputation as an engineer at stake; but to-day engines are operated in one plant where the initial pressure is 150lb. with 35lb. back pressure.

The value of the back-pressure load of the engines is, in some cases, rated so high that an electric-light plant furnishing steam heat can afford, as a matter of economy, to run simple engines, belted or direct connected to generators, and dissipate or throw away, through the medium of a large rheostat, into a stream of water the electric output of the generator and to use the exhaust steam for heating purposes.

This is being done profitably at Erie, Pa., and it is a common occurrence to start an engine with but a friction load in order to get exhaust steam to turn into the mains. In short, the point has been reached where it is doubtful whether it is the steam or the electricity that is the by-product.

MACHINE VICES.

In these days of specialisation, the place of the machine vice has, in certain instances, been taken by jigs or fixtures, specially designed to facilitate rapid and accurate production, the idea in view being of course to get the labour cost as low as possible. It will be found that cases of this description, however, are chiefly confined to manufacturing firms who are employed on a standard line of goods, such as bicycles, small arms, and motor cars, the manufacture of which entails the production in exact duplicate of large quantities of a given article before any alteration in the design of those products is likely to take place. Alterations of design would necessitate the preparation of new jigs and fixtures to suit the new form of component part, as these jigs, being specially designed to perform one or two operations at most on one size of a given article, are very limited in their capacity. This means that practically a separate jig or fixture has to be made for every operation, on every size of each different article to be completed in quantities. This is a very serious item, as the first cost is heavy, and where a very large quantity of finished parts is not likely to be manufactured before an alteration in design may take place, the cost of special jigs may prove prohibitive, and standard tools and attachments are to be preferred. Such tools are generally found in the machine shop equipment of all engineering concerns. One of the most common, and at the same time most valuable, acquisitions to the machine shop is a good machine vice, and although it cannot compete with a specially-made jig or fixture in the rate of output or accuracy of any given article, yet, on the other hand, its application is not confined to a narrow range of work, but, on the contrary, it has a very wide scope. It can be used to advantage on a large variety of work which requires holding securely whilst being operated upon, in planing, shaping, milling, drilling and slotting machines, and allows this machining to be effected in much less time than it would take to secure work by any other method, such as clamping by straps and bolts, &c.

There are various types of machine vices on the market, each maker naturally claiming some advantage, or point of merit, for his particular type. A few of the most common types are shown in Figs. 1 to 14. In addition to these, however, there are many other designs made, mostly of a special nature for certain classes of work, so that their application to the general run of work is very limited, and consequently they are not used to the extent of the designs here illustrated. Practically all the types shown are applicable to a very wide range of work, such as is found in every-day practice in the majority of shops and in every branch of the engineering and allied trades.

Referring to Fig. 1, this is a type of vice which is supplied occasionally with American milling machines, being part of the equipment, or standard outfit, included with the machine, as without a vice, indeed, the output of this, the most modern of machine tools, would be greatly curtailed. To get the full benefit of the milling machine it is absolutely necessary that it should be equipped with a good machine vice, which serves to secure the work which is being operated upon. English makers, as a rule, do not include a vice in the outfit with a milling machine, but charge it as an extra when one is supplied. This is a point well worth their consideration, as sometimes the

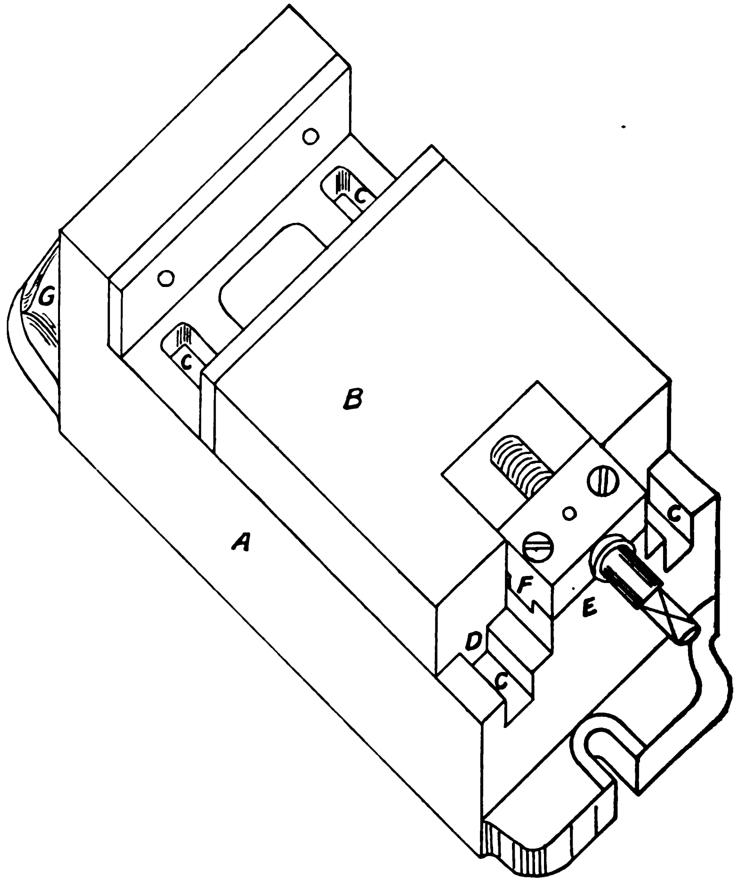


Fig. 1.

output of an expensive new milling machine is seriously restricted for the want of an efficient means of securing the work. This, as said, the keen American competitor would have supplied with the machine. The base of the vice *A* is of cast iron, and is of massive proportions, being made in different widths of jaw, from 4in. to 10in. wide and 4in. to 10in. long; the sliding jaw *B* is also made of cast iron and has two tongues machined on the bottom, marked *D*; the tongues fit into the grooves *C*, *C*, which are planed or milled in *A*, as shown. These take all side strain, and keep the sliding jaw *B* rigid and free from lateral strain when gripping up work which is not parallel, as *B* is a fixed jaw, and cannot swivel to accommodate itself to the work, should the latter be tapered. *E* is a massive bearing, the lower part of which is cast solid with *A*; *F* is the cap, with a tongue in the centre as shown, to take all the end thrust of the operating screw. This cap has a thick collar turned solid with it, which comes dead into abutment against the faced end of the bearing. The outside collar shown has no strain thrown upon it. The screw is in compression when the vice is gripped up, hence its massive proportions; it operates through a nut let into *B*. There are two strengthening ribs *G* at the back of the fixed jaw as shown, to give it additional rigidity. The hardened steel plate jaws are secured by two set screws in each, and are usually left plain, to prevent them from marking the work whilst being held.

The drawbacks to this type of vice are: Limited length, unless unduly heavy; fixed, or non-swivelling loose jaw, which can be claimed also as an advantage in some cases, such as when gripping a narrow key for instance, as it can be secured in any part of the jaw, without the latter swivelling; also, the work has got to be hammered down on to packing strips, to ensure it being exactly parallel when machined. This is often a difficult and tedious operation, as the tendency of the jaws, when gripped up, is to lift the work off the packing blocks, instead of to grip it down on to them.

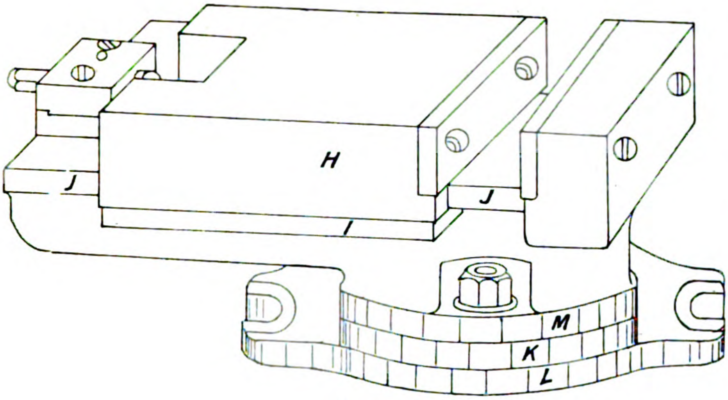


Fig. 2.

Another type of vice, very similar in some respects to the one just described, is illustrated in Fig. 2. This vice is designed with a swivel base, so as to allow it to be swivelled round at any angle to suit different conditions of work, &c. It will be observed that the design of the sliding jaw *H* is altogether different from *B*, in Fig. 1; instead of having two tongues fitting in grooves, to take the side thrust, it has two loose steel plates *I*, secured to *H* by set-screws, which form a slide against the under edge of *J*. This type is more common, and probably more rigid than and superior to the type shown in Fig. 1, as the plate or strip *I* prevents *H* from lifting. The screw and bearing are exactly the same as shown in Fig. 1; the bottom part *M* is turned circular, and fits on the base plate *L*, which has a turned boss, *K*, as shown. The base *M* is secured to *K* by the two bolts sliding in a tee slot machined in *K*. These bases are often graduated, so that the operator can set jaws at any angle to suit the work in hand.

The two slots in the end of the base are for securing the vice to the machine table. This vice possesses advantages over that shown in Fig. 1, but it has also most of the same faults already mentioned in that connection.

Fig. 3 shows a vice which has the advantage of a swivel base, and a somewhat lighter construction than those shown in Figs. 1 and 2. It has also a swivel loose jaw *N* which can be turned completely round, to grip short round stock in the vee *O*; this vice will also grip taper work of any degree of taper. It will be seen that the screw is placed low down between the slides; this passes through a nut which fits between the guides. The top of this nut has a round shank turned on, which fits in a hole bored in *N*. The top of the hole is recessed, and a lock-nut secures the jaw to the nut by screwing on the shank as shown. *P* indicates the two lock-nuts, screwed on the operating screw to take the end thrust, as it cannot have a solid collar turned on since it does not pass through a split bearing. Instead of these lock-nuts being in the position shown, the screw-end sometimes projects through the back end of the vice, which forms a bearing for it, and the lock-nuts are then screwed on the outside; in that case the back end

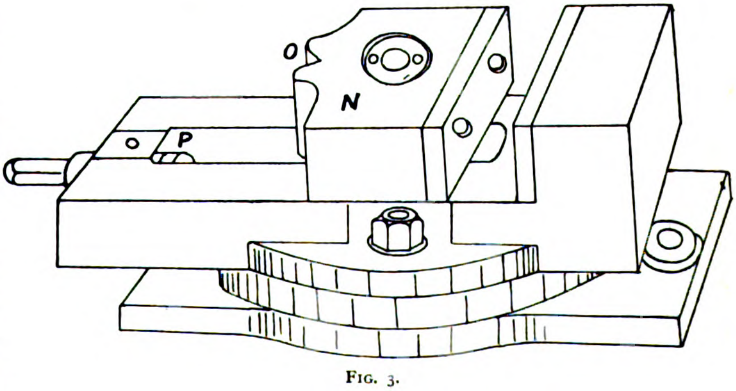


Fig. 3.

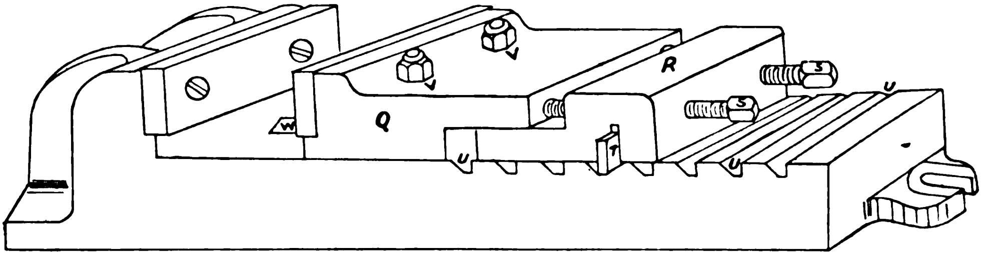


Fig. 4.

takes the pull, and the screw is in tension. Instead of the two lock-nuts, some makers, for cheapness, substitute a loose collar slotted on and held in position by a peg passing through the spindle and riveted over at the ends. This practice is to be condemned, as the round peg soon gets bent by continual slackening and tightening, which causes a lot of end play, and eventually the peg breaks or shears off. This vice also has plain jaws generally, and the tendency is to lift the work off the packings, even more than with the one shown in Fig. 2 if anything, but, nevertheless, it is a very useful vice; its capacity is limited lengthwise, as is also that of the two preceding types described.

A type of vice totally different in design from any of the preceding ones is shown in Fig. 4. This vice, not having a large central operating screw, can be constructed rather lower than the others, and this tends towards rigidity. Its chief advantage, however, lies in the fact that its capacity longitudinally is much greater than those already described; on the other hand, its disadvantages are numerous, and it has never been adopted very extensively. It is heavy and clumsy, has a lot of working parts, and is consequently liable to get out of order, and it is an expensive vice to manufacture. Referring to the illustration, *Q* is the sliding jaw, which is of the non-swivel type; *R* is a dog which carries the two clamping screws *S*, *S*; the under side of this dog has a slot milled across it, in which the steel key *T* is a nice sliding fit; this key drops in the slots *U*, which are milled across the vice base as shown. This construction prevents *R* from moving when the two operating screws *S*, *S*, are clamped up against the sliding jaw *Q*. The latter is kept in position by two bolts, *V*, *V*, and nuts, the bolt-heads sliding in tee slots milled in the base; one of these slots can be seen at *W*. For gripping work of a varying character in length, the key *T* is withdrawn and the loose jaw *Q* adjusted, when *T* is again inserted in the nearest slot *U*. This vice is chiefly used on planing machines, and is made with jaws up to 10in. wide.

Fig. 5 shows a vice also of a quite different design from any of the others described. The chief feature of this vice lies in the fact that there is no clamping or central screw as in most other vices, but a bolt and nut *Y* instead. This bolt passes through an elongated hole at an angle as shown, and clamps the sliding swivelling jaw *X* up against the work, at the same time having a tendency to draw the jaw downwards and pull the work down on to its supporting packings; this is, of course, an advantage, if the downward movement really is sufficient to perform that function. *Z* is a slot cored through the base, to allow the bolt *Y* to slide in, the details of which may require some explanation: at the bottom of the slot *Z* a rack is cast on either side, into which the teeth *b*, Fig. 6, cast on the dog *a*, engage. The swinging clamping bolt *c* is pivoted on the pin *d*. The end elevation is shown in Fig. 7 with the bolt removed. By

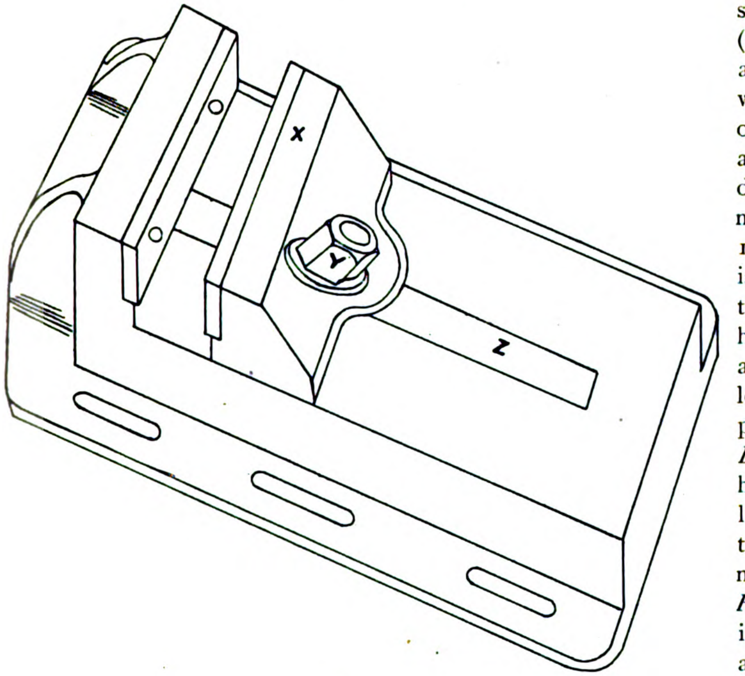


Fig. 5.

slackening the bolt, the teeth in the rack disengage with those in the dog *a*, the loose jaw *X* being then free to slide up and down; it is therefore quickly adjusted to extreme lengths within its capacity. By swivelling the jaw *X* right round and using two vices of the same size on long planing machine tables, long slides, &c., can be gripped up which cannot be held in any single vice. In such instances there is no fixed jaw, of course, but a loose jaw at each end of the work, turned round, the work being packed up in the centre, and supported on the bases of the two vices at the ends. This vice, having very few working parts, is exceptionally cheap to manufacture, a point which is, of course, very much in its favour.

A type of vice which has been very extensively adopted in Europe is shown in Fig. 8. Commonly known as the Taylor pattern, it is, in one or two respects, similar to that shown in Fig. 4, of low build, and of long capacity. In the diagram, *e* is a cast iron, swivelling, sliding jaw (also shown in Fig. 9), *f*, *f* are the steel jaw plates which are a special feature of this vice. These jaws are known as the "pull down" type, and their mechanism is shown in Fig. 12. The vice jaw casting is indicated at *A*, *B* is the steel jaw plate, *C* is a hole drilled in *A*, *D* is a short grub screw, *E* is a long cheese-headed screw passing into the jaw plate *B*; the bottom end of the hole *C* is drilled about $\frac{1}{8}$in. larger in diameter than *E*, to allow of a compensating movement. The coil spring *F* is slotted on *E*, to force it back and keep *B* up against the face of *A*. *G* is a flat bow spring, shown also in Fig. 9, which is dropped in a milled slot, and forces the jaw plate *B* up as high as the screw *E* will allow it. Oily dirt and grit should be occasionally cleaned out of this aperture under *B*, otherwise it will accumulate and prevent *B* from exercising its "pull down" action, which is as follows: When the vice is gripped up, *B* is at its highest position,

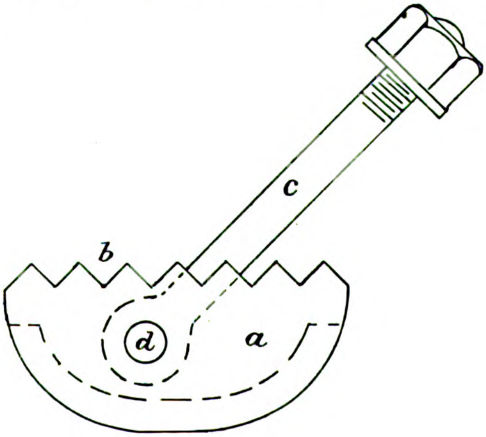


Fig. 6.

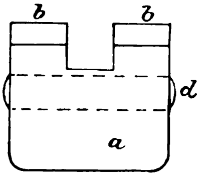


FIG. 7.

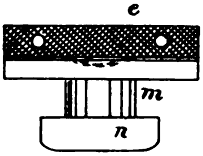


FIG. 9.

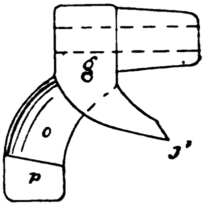


FIG. 10.

through the action of *G;* as soon as the pressure is increased, *B* commences to slide downwards, as the back face is tapered; this action draws the work down firmly on to its supports, without any hammering whatever, which is a great advantage much appreciated by the workman as a time and labour saver.

Upon reference to Fig. 8 again, *g* is an adjustable dog, which carries the clamping screw *h*. A side and front elevation of *g* is also shown at Figs. 10 and 11. Equidistant slots *i* are milled across the vice base, similar to those shown in the vice at Fig. 4; *j* is a slot cored up the centre of the vice; j^1, Figs. 10 and 11, engage in the slots *i*, and firmly locate the instantaneous adjustable dog *g*. The two projections *k*, *k* on the edge of the vice base are planed up dead square with the jaws, and act as a guide for setting the vice; this is a good feature, and most vices now possess it. There are four grub screws, as shown at *l* in Fig. 8 for the pull down jaws. Fig. 9 shows the turned shank *m*, which fits inside the slot *j* and is prevented from lifting up by the head *n*, and which slides under two machined faces at the bottom of *j*; *e* is thus free to swivel for gripping taper work, which, whilst an advantage in some cases, has the drawback that it cannot grip a narrow article at one side of the jaw unless a packing of equal length be inserted at the opposite side. The dog *g* has on it a shank *o*, which passes through *j* and has a tee head *p*, on the bottom, set at an angle, as shown in Fig. 10. By tilting *g* forward, which lifts the point j^1 up, the taper on *p* allows it to draw clear of the rack *i*, and it can be adjusted instantaneously; *g* can also be twisted round and lifted away from the base. One of the drawbacks of this vice is that the clamping screw *h* is sometimes made too small in diameter,

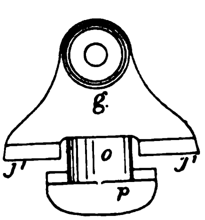


FIG. 11.

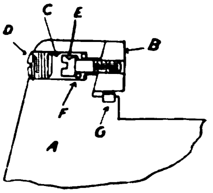


FIG. 12.

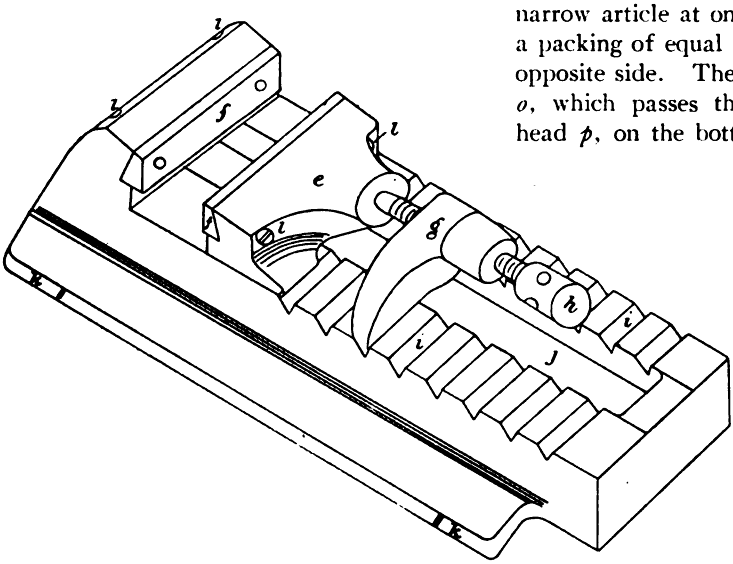


FIG. 8.

and consequently breaks off close up to the head. The four holes in the screw head for the tommy bar are often drilled too small, with the result that the bar end has to be turned down very small, and it is therefore liable to get bent by continual slackening and tightening. The dogs ought to be made of cast steel, as cast iron is liable to get broken, due to the rough usage to which it is usually subjected.

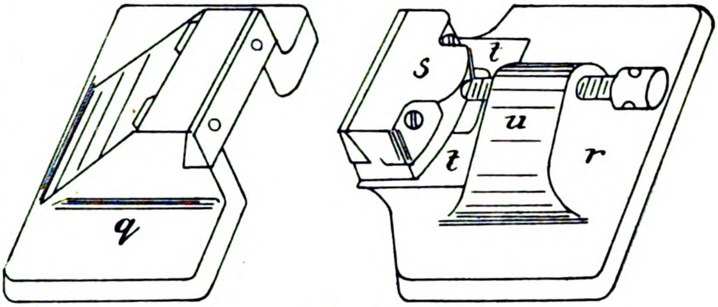


FIG. 13.

Fig. 13 shows a "split" or "divided" vice, for taking in work of unlimited length. This vice also possesses the same features as the previous one, and is very useful for clamping on long planing machine tables for gripping long slide bars, &c. The vices are light and handy; the part *q* is simply a fixed jaw, whilst *r* is the base for the sliding jaw *s*, which is practically the same as shown in Fig. 9; *t*, *t* are the machined sliding faces; *u* is a bracket cast solid on *r*, which takes the place of *g* in Fig. 8, and through which the clamping screw passes. The jaw *s* is free to swivel, and is instantly detachable. These split vices are cheaply made, and have, of course, a much greater capacity than any ordinary machine vice; indeed, their working limit is only governed by the length of the machine table upon which they are clamped.

A vice designed to possess the same features as the split vice just described is shown at Fig. 14. In this type both jaws are movable instead of there being one fixed jaw as in the last case. Referring to the illustrations, *v* shows the bases and *w* the sliding jaws, which, instead of being parallel to the bottom, are placed at an angle, as shown, and operated by the screws *x*. The clamping-down holes *y* are usually slotted. The advantage of this split vice is that when the length of the machine table is limited it takes up less room in cramped positions, since the jaws can be drawn back right over the base, and thus allows the machine to take in longer work. A great drawback, however, is that the back of the jaws and the screws *x* project much higher than the front of the jaws, where the work is gripped; this prevents a clear, uninterrupted cutting space at each end of the work, unless the latter is packed up very high, which is not always possible, and which in the case of a planing machine is rather dangerous and calls for the constant atten-

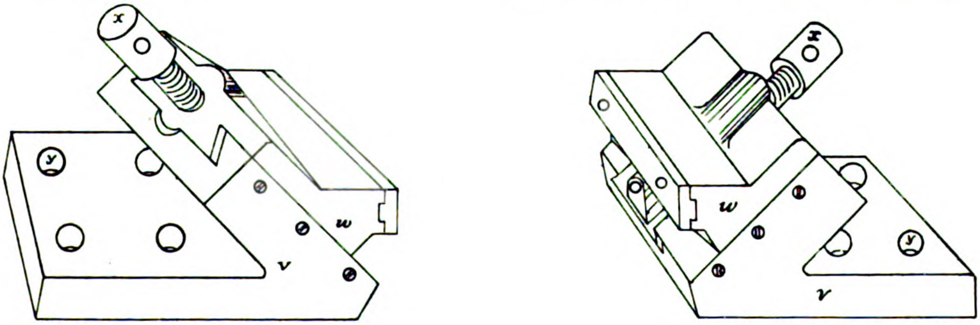


FIG. 14.

tion of the operator in charge. The jaws of this vice are not similar to those shown in Fig. 13, but the slides, being angular, are supposed to cause the jaws to grip the work down on to its supports when the screws *x* are tightened up, the movement of the jaws not being parallel, but as they close in they also move down the incline on the top of the base *v* and grip the work down on to its supports.

The depth of jaw in most of the machine vices here described and illustrated varies from ¾in. to 3in. deep, according to size and capacity, but vices with special jaws up to 6in. deep are often used on certain classes of work; a common depth of jaw, however, for general and miscellaneous work is from 1¼in. to 2in., according to the size of vice employed. A common width of jaw in most general use is from 4in. to 6in., taking in work between the jaws from 10in. to 16in. long; but, of course, the capacity of a vice for any particular service is determined entirely by the work for which it is intended. When using a machine vice it is generally considered a good practice to let the work being operated on be supported on two parallel planed strips, put crossways between the jaws, spanning the two sides of the base, instead of resting it direct on the two planed side members of the vice, where the slots are milled across, and where a large amount of the supporting surface is thus taken away.

An important item to bear in mind when using a machine vice is to secure it in position on the machine table, so that the fixed or solid jaw should take the cutting strain or end thrust, as this relieves the loose jaw and other movable working parts from excessive wear and tear; in the case of a shaping machine it is not often convenient to have the vice fixed in this position, as the operator requires to have the adjusting screw which secures the movable jaw up to the work, at the outside edge of the machine table, so as to enable him rapidly to slacken and tighten the screw, and withdraw and put fresh work in the vice. When securing work in the vice it should be fixed as low down as convenient, so as to bring the edge which is being operated on as near the top of the vice jaws as possible; if the work is deep and projects a long way above the top of the vice jaws excessive vibration and chatter take place, and in consequence the quality of work and the output are reduced, since heavy cuts cannot be taken safely.

Accuracy is a quality that all machine vices should possess to a high degree, as upon that the quality of the product turned out is entirely dependent; good work cannot be produced in a badly made vice. Most engineers recognise this, and instead of making them in their own works buy them from tool makers who specialise in this class of work, and who have a reputation for high-class work.

In the heavier branches of the trade, such as locomotive, tool, marine engine, and work of a miscellaneous character, the machine vice is not likely to be superseded, but will always claim a field for its operations which cannot be filled by any other device or attachment.

* * *

SULZER DIESEL MARINE ENGINES.

Of the raw materials used for the production of mechanical energy, liquid fuels long held but a secondary position, although they were known many years before the discovery of coal. It has been reserved for modern engineering to find their wider application and ensure their rational utilisation.

For several decades past liquid fuel has been used for industrial purposes, though only to a limited extent. Crude oils have been employed for the heating of steam boilers for a very long time in countries such as Russia, Galicia, Roumania, and North America, all of which possess their own oil-fields. Liquid fuel compares extremely favourably with all solid fuels by reason of its high heating value, comparatively small bulk, complete combustion, low price, and its exceptional facilities as regards transport and storage. It is chiefly due to these advantages that oil-fuel has been so largely adopted on battleships, &c. The State railways of Austria-Hungary and the Mexican railways also, according to recent reports, have decided to have their engines adapted to burn liquid fuel.

From the purely technical point of view, this method of using liquid fuels only marks a small advance, inasmuch as a steam boiler is always necessary for the utilisation of the heat energy contained in the fuel. Technically, a better solution of the problem is the present method adopted in the Diesel engine, in which neither furnaces, boilers, nor gas generators are required, and the heat energy is directly converted into power.

As regards the localities and output of the various oil-fields, there appears to be a lack of general information, but the accompanying map (Fig. 1) shows that they exist in almost every country, and according to statistics their total output was as follows:

Year.	Output.
1900	over 19 million tons.
1906	,, 28 ,, ,,
1907	,, 35 ,, ,,

Several new and extensive oil-fields having been opened since these statistics were compiled, the total output for the years 1908 and 1909 will be considerably in excess of these figures.

The success and ever-increasing popularity of the Diesel engine is proof that as regards working economy, safety, and simplicity it meets all requirements, and is superior in many respects to former designs of heat engines. For this reason it was desired to adapt the Diesel engine for marine purposes, and in Russia there are already many cargo-boats which derive their motive power from Diesel engines. The type of engine employed so far was the stationary type, in which the direction of motion could only be reversed by means of special couplings or by reversing the propeller blades. The Diesel engines hitherto employed for driving boats can therefore hardly be called marine engines.

The question of direct reversal in the Diesel engine was solved for the first time in a practical manner by Messrs. Sulzer Brothers in the year 1906, when they placed their direct reversible Sulzer Diesel marine engine on the market.

In contradistinction to former internal combustion engines, in which, as already mentioned, reversal was obtained by means of intermediate mechanism, the Sulzer Diesel marine engine (Fig. 2) is directly reversible like a steam engine. The engine is rigidly connected to the screw shaft and runs in either direction. The engine is single-acting, and works on the two-stroke principle, as follows :—

On the upward stroke of the piston, as in the four-stroke cycle, the compression of the air in the cylinder is effected to such a degree that the heat produced is sufficient to ignite the fuel spontaneously on the introduction of the latter into the cylinder. During the downward stroke of the piston the fuel is admitted in the form of a spray, and is gradually burnt as it enters the cylinder. On completion of the expansion large ports in the wall of the cylinder are uncovered by the piston, the scavenging air-valves in the cylinder cover are then opened and the expanded combustion gases expelled by means of the scavenging air-pump. The accompanying indicator diagram (Fig. 3) shows the method of working.

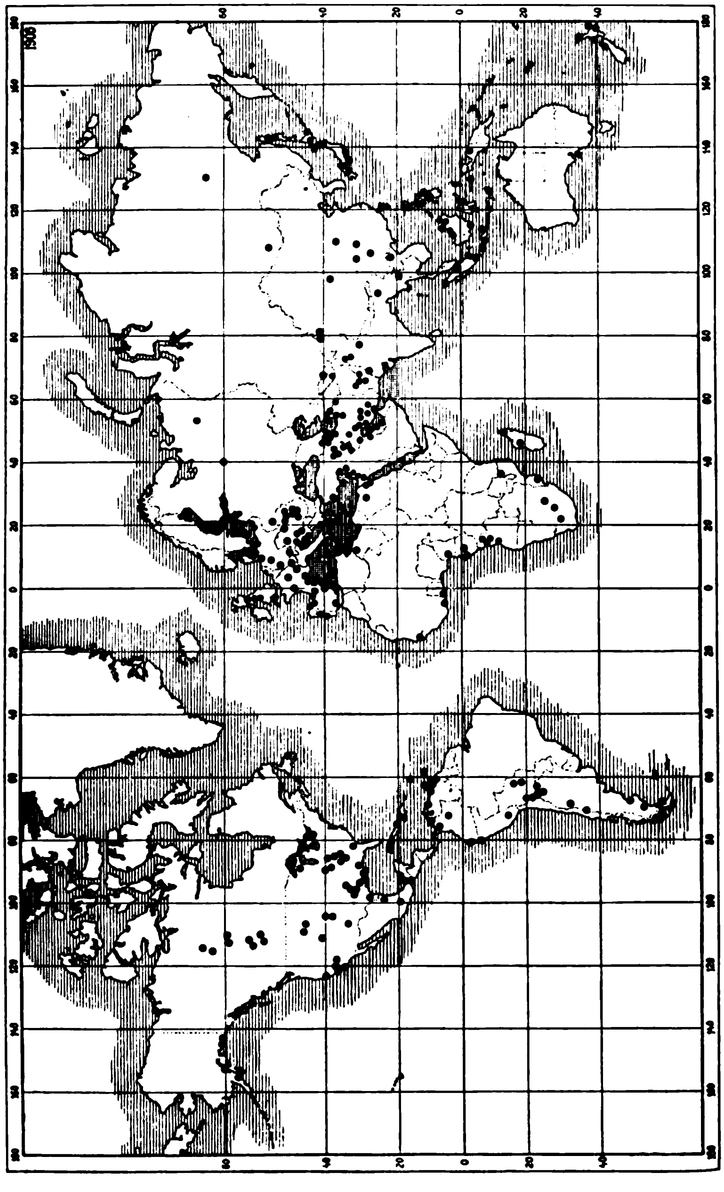


Fig. 1. Map showing the Most Important Oil-producing Countries.

First Stroke: Compression and heating of air (Curve 1-2); *Second Stroke*: (Working stroke) Combustion (2-2′); Expansion (2′-3); Exhaust of combustion gases and introduction of pure air (3-1).

The two-stroke engine differs from the four-stroke engine inasmuch as the latter requires two complete revolutions for one working stroke, whereas in the two-stroke engine each revolution produces a working stroke. With cylinders of equal size, therefore, the two-stroke engine will give approximately double the power produced by a four-stroke engine; or, expressed differently, for any definite power required the two-stroke engine will be much the smaller.

In addition to the saving in weight thus effected, there is also the economy in space, which is of particular importance on board ship. In the latter case there is also the further consideration of space economised on account of the liquid fuel requiring less room for storage.

The engine is usually made with four cylinders, which not only ensures a perfectly uniform turning moment, but enables the engine to be started with certainty irrespective of the position of the crank. Besides the working cylinders the engine is supplied with an air-pump for the highly compressed air for starting, reversing, and the injection of the fuel, and, further, with a low-pressure scavenging air-pump. Important accessories to the engine are the three steel vessels for the reception of the compressed air (for starting and injection purposes). The engine is of the enclosed type, but the various parts, such as cranks, bearings, pistons, &c., are readily accessible by means of removable doors.

The engine can be reversed in a few seconds. When starting, the hand-wheel, shown on the right of the engine in the illustration, is turned and admits compressed air into the cylinders. A further movement of the wheel puts the starting-valve out of gear, at the same time opening the fuel-valve, so that the engine starts working. In the reverse manner the engine is stopped and reversed. The starting-valves and fuel-valves are operated by oscillating eccentric cams, the motion of which

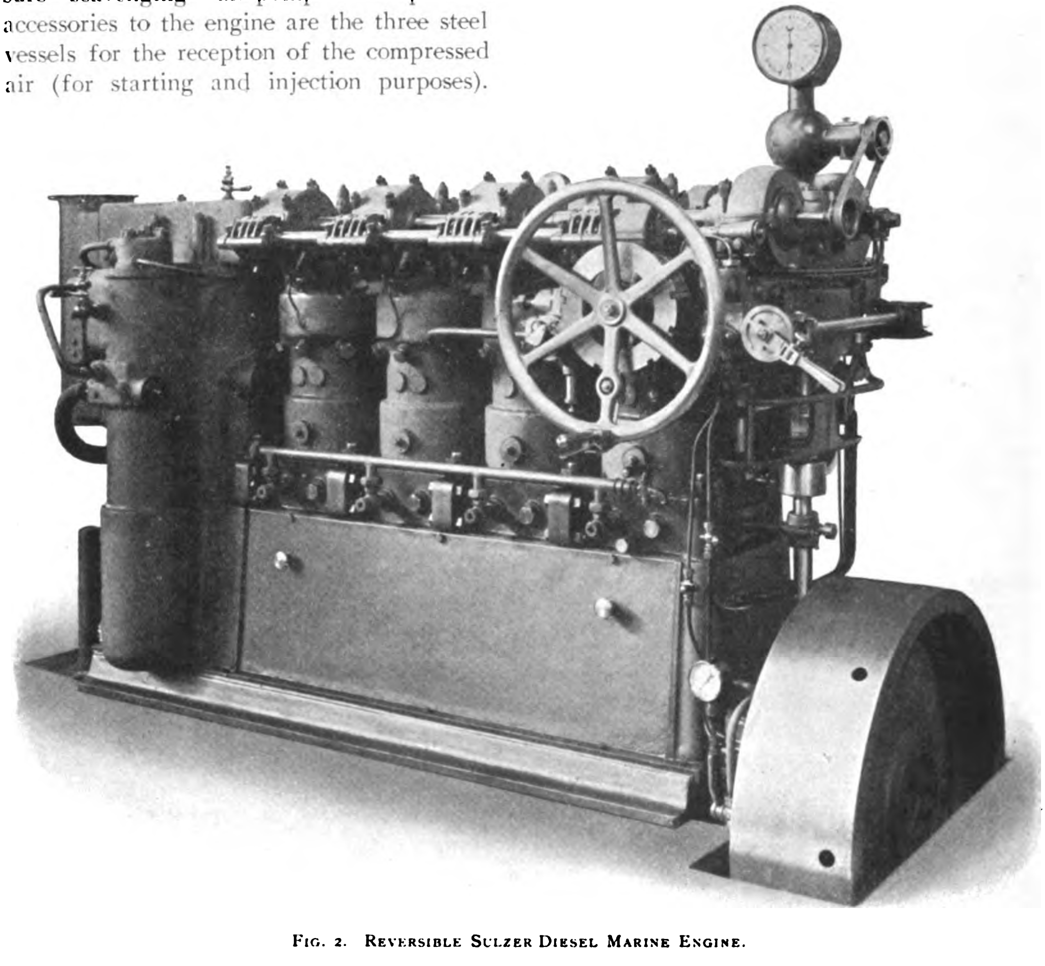


FIG. 2. REVERSIBLE SULZER DIESEL MARINE ENGINE.

is determined by the motion of the reversing shaft according to the direction of the engine, whether running or at rest. All reversing operations are conducted from the hand-wheel referred to above, and may follow one another very rapidly, thanks to the simple and practical combination of the reversing mechanism.

The small space required by the Diesel stationary engines is already a decided point in their favour, but the absence of furnaces, coal and cinder transport, and above all, the absence of smoking funnels is of the very greatest importance on board ship, and are advantages which can hardly be over-estimated. Danger from fire and explosions is also non-existent. The fuel, consisting of mineral oil residues (Mazout) and the cheap by- and intermediate-products of oil refineries and gasworks, is easily stored in the double bottoms of ships and in the ballast tanks. It can be readily taken on board either by means of pump and hose or by means of compressed air, so that no difficulty is experienced in transferring liquid fuel even on the high seas.

In proportion to its high heating value crude oil has a remarkably small bulk, as may be gathered from the fact that about 1,000,000 B.T.U. of crude oil only require a space of 1 cubic ft., while 1,000,000 B.T.U. of good hard coal would require about 1.35 cubic ft. With similar storage capacities, therefore, approximately 35 per cent. more energy can be carried, and if we also take into consideration the circumstances that the Sulzer Diesel two-stroke engine only consumes about ½lb. of fuel per b.h.p.-hour the radius of action of a ship is considerably increased. A further considerable saving in fuel is effected by reason of no fuel being used while the engine is at rest, and further on account of the automatic fuel feed the working of the engine is entirely independent of the capability of the mechanic. The cost of fuel consumption per b.h.p. is about one-tenth of a penny, reckoning the price of oil in England at 40s. to 45s. per ton.

General interest will be awakened by the results which have been obtained with a 150 horse-power engine recently supplied to the Steamship Company in Zurich. The company in question having a steamer which was useless for regular service on account of its slow speed determined to have it fitted with a more powerful engine. The speed of this particular steamer was hardly 8¾ miles per hour, whereas the present time-table demanded a speed of 11¼ miles per hour at least. The displacement remaining unaltered, this increase of about 30 per cent. in speed would have meant a 2½ times increase in the output of the engine. The new plant was to fit into the space of the old one, and the weight was not to exceed the weight of the old plant; the working expenses also were to be cut down as much as possible. It was not difficult to foresee that the substitution of a new steam plant for the old one would not have answered the purpose with any degree of certainty—in fact, the only possible way of attaining it was by the introduction of a Diesel engine. Preliminary investigations of this plant soon offered abundant proof that the conditions laid down as regards both speed and economy would be fulfilled.

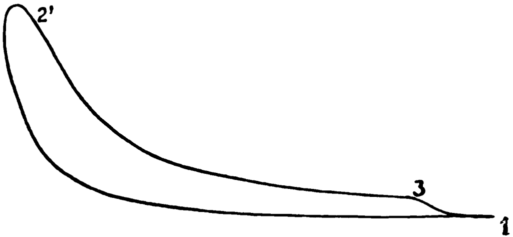


Fig. 3. Indicator Diagram from a Sulzer Diesel Marine Engine.

The Diesel engine was fitted in the early part of this year. The steamer has done regular daily service since the end of July, and the results of the trials have exceeded all expectations, *inasmuch as a speed of over 12 miles per hour is obtainable, while the cost of fuel has been reduced to one-fourth.* It must, however, be taken into consideration that the engine which was replaced by a Diesel engine was made many years ago, although on the whole the comparison holds good for a new steam engine of modern construction.

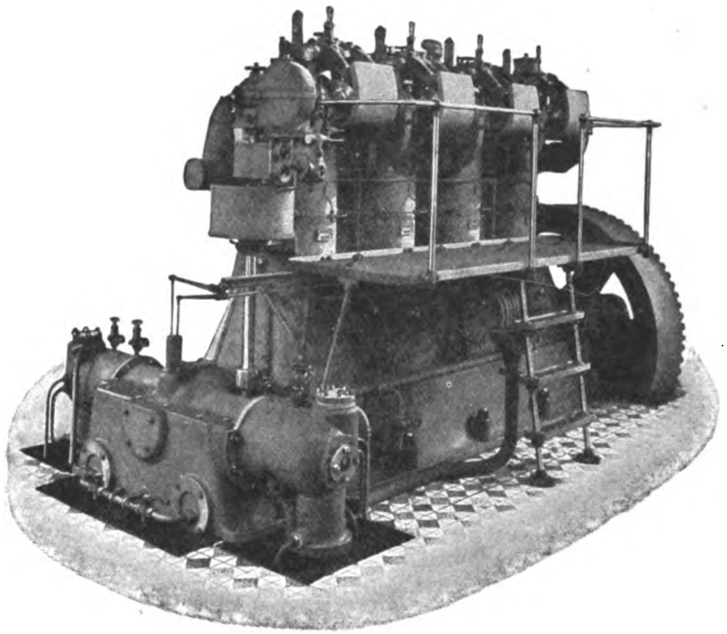


Fig. 4. Sulzer Diesel Engine for Lighting and Pumping Purposes on Board Ship.

Compared with the old steam plant the output of the engine has been doubled. The amount of fuel carried is sufficient for the steamer to travel ten times the distance hitherto possible, and this at an increased rate of speed; at the same time a saving in weight of 35 per cent. has been obtained.

The trial trips which were carried out by the Steamship Company took place on September 30th last. The trial course measured exactly 24 kilometres (14.9 miles). The fuel consumption was regulated by a decimal weighing apparatus, and it may be mentioned that the measurement of fuel as compared with that of coal is almost mathematically exact. The fuel used was Galician petroleum, the present price of which in Zurich is about 48s. per ton.

At a speed of 12½ miles per hour, the cost of fuel was 1½d. per mile, the cost of fuel per b.h.p.-hour under similar conditions being .139d. The further working costs will also be considerably less than with the steam plant, as there is no boiler to maintain, and all expenses connected with cleaning, repairs, and attention to same are therefore entirely obviated.

In addition to supplying the motive power, Diesel engines may also be used to advantage on board ship for lighting and pumping purposes. Such an engine is shown in Fig. 4, and is designated a high-speed engine by Messrs. Sulzer Brothers. It works on the four-stroke cycle, and in design is somewhat similar to the standard type of stationary engine. The engine, similar to the marine engine described above, is usually constructed with four cylinders, which ensures the perfect balance of the moving parts. In view of the high number of revolutions, the bearings and wearing parts are of exceptionally substantial design. The compactness which is a feature of all Diesel engines is especially noticeable in the height of this engine, and is a decided advantage.

For ship-lighting or bilge-pumping purposes the Diesel engine can be coupled direct to a dynamo or centrifugal pump above the water line and thus forms an independent unit, an advantage which it would be difficult to over-estimate in the event of the engine-room being flooded and the main plant put out of gear.

P. Jacoby.

THE THEORY & COMMERCIAL USE OF THE MERCURY ARC RECTIFIER.

THE matter of converting alternating electric current into that of a continuous or direct-current nature is one that has been the cause of the development of much electrical machinery, not only in the shape of mechanical and chemical rectifiers, but also, and chiefly, various types of motor generators. The following remarks regarding a new form of rectifier should be found interesting, since this apparatus is dependent upon an entirely different principle from that of either the mechanical or chemical types. The medium playing the important part in this form of rectifier is ionised mercury vapour. This type of rectifier has been in use for a few years, and is becoming very popular on account of its simplicity and reliability.

Construction.

An exhausted tube (Fig. 1) is provided with mercury electrodes—W, X, and Y; X is termed the cathode, and contains a quantity of mercury, as shown, while WW are termed anodes. Alternating current being supplied to WW causes the cathode to generate ionised vapour when in a state of excitation. This state of excitation can only be maintained so long as there is current flowing towards the cathode from W.

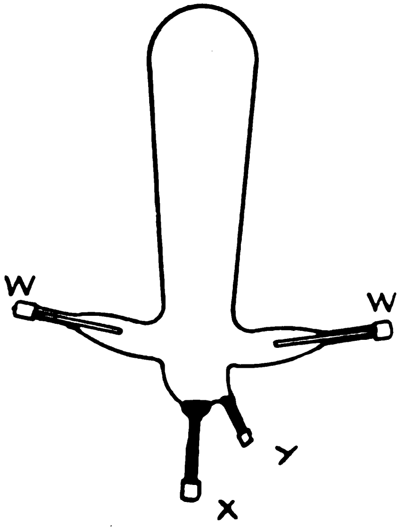


Fig. 1. Mercury Arc Tube.

When the direction of the applied voltage is reversed (which, of course, occurs once during every cycle) the current ceases to flow, since, in order to flow in a reverse direction, it would require the formation of a new negative electrode. Thus the current always flows towards X, which is kept by the current in the necessary state of excitation. It will be readily understood that such apparatus would be unworkable if means were not provided to maintain the flow of current towards X, since at every half-cycle the voltage becomes zero. To meet this requirement, WW are connected to the line through an adjustable compensating reactance; thus, as the current alternates, the anodes alternately become positive, and there is a continuous flow towards the cathode. At each reversal the reactance discharge maintains the arc, until the applied voltage reaches the necessary value to maintain the current against the counter E.M.F. of the load. In this way a true continuous current is produced.

Starting the Arc.

For starting purposes, the tube is provided with a small starting anode (Y, Fig. 1) containing mercury, and connected through a resistance to the line. A slight tilting of the tube causes the mercury to bridge between X and Y, and in consequence of the rocking an arc is started between these electrodes, which is immediately taken up by the main electrodes WW.

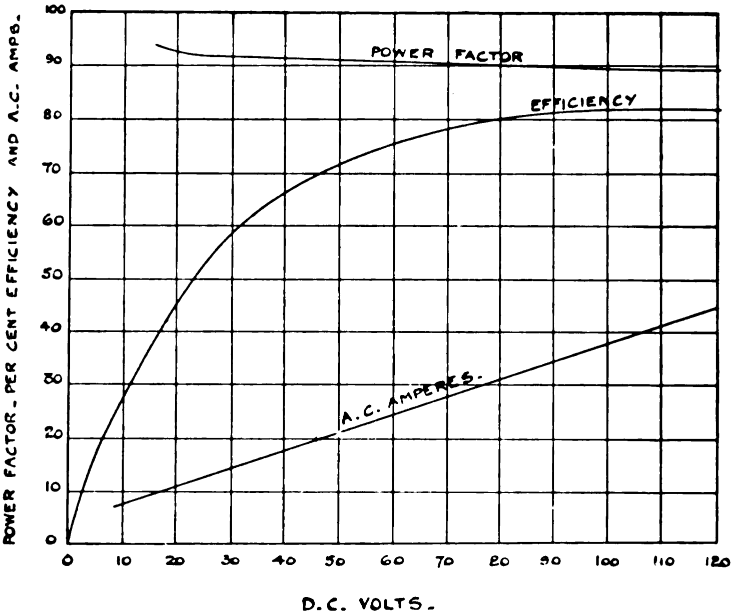


Fig. 2. Rectifier on 110-volt A.C. Circuit.

Commercial Uses.

The commercial use of the arc rectifier at the present time is mainly in the charging of storage batteries from an alternating current source, though there is no reason why small lighting and power installations could not be equally well supplied from such apparatus if desirable. It is evident what advantages this form of converter has over those of the mechanical type, not only on account of the saving involved due to the small amount of attention required, but also on account of the very small space occupied by the complete equipment.

Efficiency and Power Factor.

A reference to the curves in Figs. 2 and 3 will show the approximate values of the efficiency and power factor of a mercury

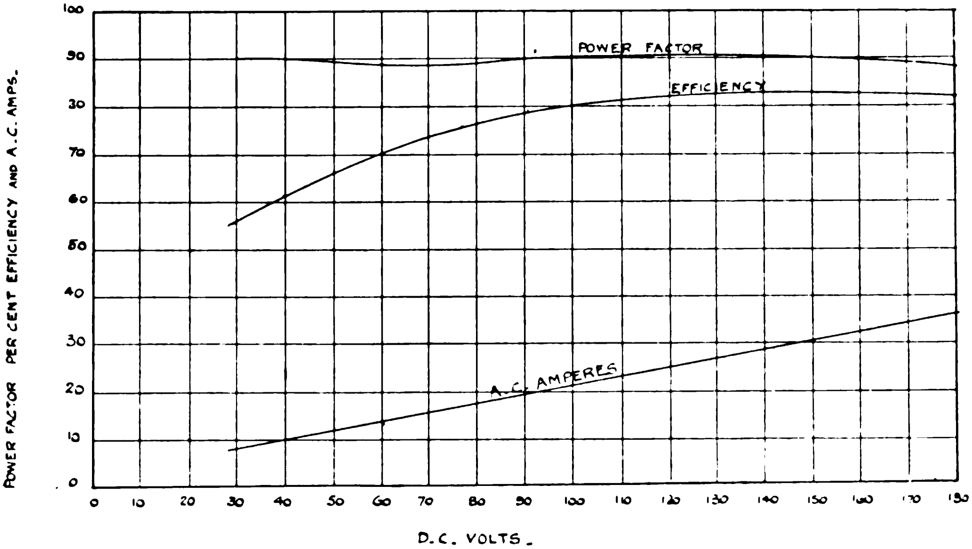


Fig. 3. Rectifier on 220-volt A.C. Circuit.

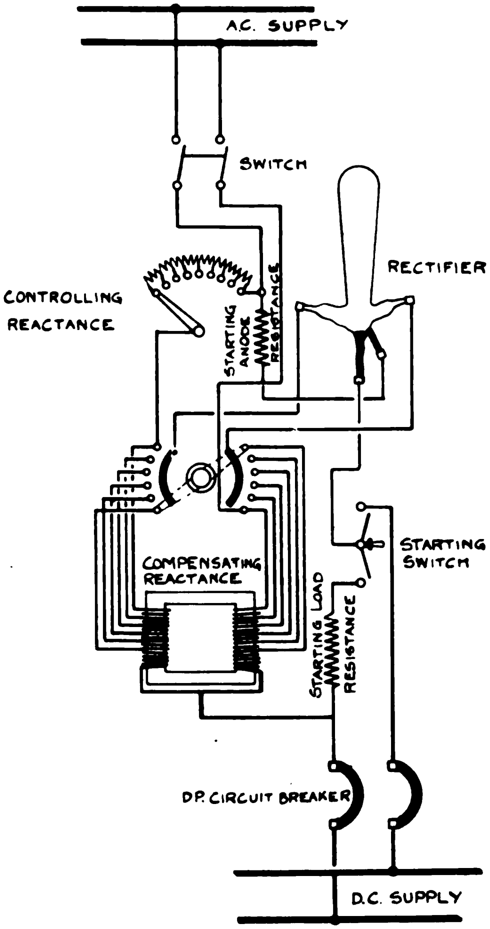


FIG. 4. CIRCUIT CONNECTIONS OF RECTIFIER.

arc rectifier tested on 110 volt and 220 volt, 60 cycle, single-phase circuits, and clearly indicates the connection between A.C. amps., efficiency, power factor, and D.C. volts with various loads. These curves show that an average power factor of approximately 90 per cent. is produced on either voltage, the value tending to fall as the load increases.

Since the loss in the arc remains constant, the efficiency of the rectifier varies with the direct current voltage delivered, increasing as this voltage increases; and a further reference to the curve (Fig. 3) will show the connection between these two quantities, and also that an average working efficiency is maintained of approximately 70 per cent., from about one-quarter to full load, when supplying a direct current voltage averaging 80 volts.

These values of efficiency are somewhat below the average values obtained, and the relations between the quantities hold good with tubes of any capacity, although slight variations are sometimes found, due to differences in the manufacture of the tubes; the exact efficiency also varies with every change of connection of the reactance.

Range of Operation, &c.

Different tubes are used for different alternating or direct current voltages and outputs, and the figures in the table below are arranged to give some idea of the range of operation of various tubes:—

TABLE SHOWING RANGE OF OPERATION.

A.C. Volts.	Range	
	D.C. Volts	D.C. Amps.
110	15 to 45	10 20 30 40
220	45 to 115	10 20 30 40
330	90 to 175	10 20 30 40

As regards the ratio of A.C. to D.C. power, it is, generally speaking, found that, approximately, the proportion of direct current to alternating current voltage varies from 20 to 50 per cent., while the quantity of the direct current varies from 40 to 70 per cent. of the alternating current.

With regard to the frequency of the supply, the mercury arc rectifier may be used on circuits whose periodicities vary from 25 to 140 cycles per second, the efficiency being rather higher on the lower frequencies.

For multiple operation, one or more rectifiers are connected in parallel across the A.C. and D.C. supplies, so that on a three-phase system three rectifiers connected each across one phase, and supplying common D.C. bus-bars, form a convenient and suitable method of converting alternating current from a three-phase system. The average life of the exhausted tube is at least six hundred hours.

Controlling Gear.

The complete gear for the control of one of these rectifiers consists of the following apparatus :—

(1) Double-pole automatic circuit-breaker for the D.C. supply, to isolate and protect the rectifier from the direct current side.

(2) Double-pole switch, to isolate from A.C. supply.

(3) Starting switch for introducing starting anode and resistance.

(4) Compensating reactance with adjustable switch for maintaining the rectifier arc at each reversal of current, and for varying the relation between the A.C. and D.C. voltages.

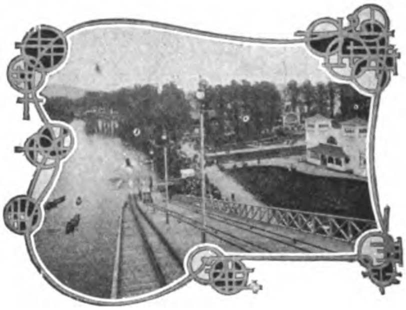
(5) Controlling reactance and switch for varying within small limits the relation between the A.C. and D.C. voltages.

(6) Starting resistance introduced at starting the arc by the starting switch.

(7) Direct current ammeter to measure current delivered.

(8) Direct current voltmeter to measure D.C. volts.

Fig. 4 shows the connections of a rectifier and controlling gear in circuit, the latter being usually mounted on a small slate or marble panel, with the rectifier tube at the back, provided with the rocker handle for starting purposes, passing through to the front. The whole converter and controlling gear, monopolising not more than a space of approximately 5ft. by 2ft. 6in. by 1ft. 6in., gives to this class of rectifier a distinct advantage over other types, where a rectifying plant of large capacity is not the requirement.



CONSTANT CURRENT ELECTRIC TRACTION.

WHILST the series, *i.e.*, constant current, variable voltage system using direct current may not lend itself readily to the distribution of energy for general lighting and power service, yet it might be suitable for long-distance transmission in bulk from one point to another without branch lines or intermediary distribution. Several applications of this system have been made in the past in Europe, but the advantages of direct current high tensions over alternate current high tensions were not sufficient to ensure the adoption of the series system in cases where it would seem to be quite suitable. The attention of the engineering world to the advantages of the series system for traction for mountain or heavy gradient lines has been aroused by the discussion of the committee appointed to consider the electrification of the Swiss railways.

In spite of the numerous advantages of the series motor as a traction motor, when supplied with constant current, it seemed difficult to employ the principle, because all the machines, generating or receiving, would need to be connected in series, and also because of the great ohmic loss in the line, which remains constant at any load. The series motor is, however, better than any other for providing a regeneration of energy feeding back into the system when

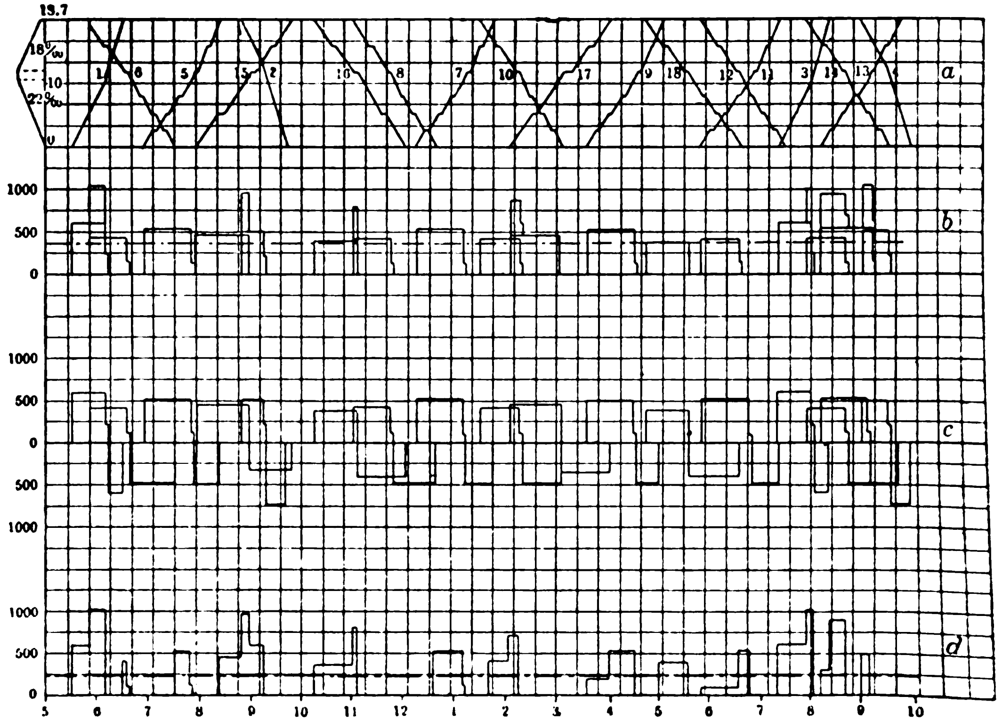


FIG. 1. TRAIN SHEET.

TABLE I.

TRAINS NO.	Section 1: 10 miles. Grade 22%.		Section 2: 1.25 miles. Grade 0.		Section 3: 7.5 miles. Grade 18%.	
	Speed. Miles per hour.	Time. Min.	Speed. Miles per hour.	Time. Min.	Speed. Miles per hour.	Time. Min.
1 and 3	15	40	31	2.5	25	18
2 and 4	25	24	31	2.5	15	30
5, 7, 9, 11, 13	12.5	48	21.5	3.5	18.5	25
6, 8, 10, 12, 14	15	40	21.5	3.5	12.5	36
15 and 17..	11.5	53	15	5	12.5	36
16 and 18..	12.5	48	15	5	11.5	40

coasting downhill and improving the efficiency of the distribution; this fact tending to justify the use of the series system on hilly tracks.

In order, however, to apply this system it is necessary to design special apparatus for the connection of the train motors with the transmission lines, so that the motors of all the trains running simultaneously would be placed in series. It will be seen that the devices suggested by Mr. Potterat, of Berne (Switzerland), and of which some particulars appeared recently in the *Electrical World*, are not more complicated than many others in general use to-day in central stations. Mr. Potterat studied the application of this system to a 32-mile heavy traffic line in the south of France, over which fifteen 200-ton trains run daily in either direction, and he has shown that it compares very favourably in every way with the single-phase system.

The following considerations are based upon a line 18.75 miles long, with light traffic and two gradients of 2.2 per cent and 1.8 per cent. converging to a plane of 1.25 mile, as shown in Fig. 1. Table 1 gives the speed in both directions, as well as the time of the different trains running on each section of the line. All of these trains are supposed to be composed of a 100-ton locomotive with tender, drawing cars aggregating in weight 200 tons.

The tractive forces in pounds per ton for the locomotive fl and the cars fe have been calculated by the following formulæ:—

$$fl = 3.970 + 2.840V\,(1.6\,V + 50)\,10^{-3}.$$

$$fe = 3.530 + 1.630V\,(1.6\,V + 50)\,10^{-3}.$$

where V is the speed in miles per hour.

The values of these forces as well as the total force applied to each train are shown in Table II.

TABLE II.

TRAINS NO.	Section 1.		Traction Forces in lb.	Section 2.		Traction Forces in lb.	Section 3.		Traction Forces in lb.
	Speed.	Grade.		Speed.	Grade.		Speed.	Grade.	
1 and 3	15	+.022	16,300	31	..	3,000	25	−.018	9,450
2 and 4	25	−.022	12,100	31	..	3,000	15	+.018	13,700
5, 7, 9, 11, 13	12.5	+.022	16,800	21.5	..	2,200	18.5	−.018	9,900
6, 8, 10, 12, 14	15	−.022	12,800	21.5	..	2,200	12.5	+.018	13,500
15 and 17	11.5	+.022	16,000	15	..	1,760	12.5	−.018	10,250
16 and 18	12.5	−.022	12,900	15	..	1,760	11.5	+.018	16,000

Tables III. and IV. give, respectively, the horse-power corresponding to these forces and the power in kilowatts calculated on the basis of a mechanical efficiency of 80 per cent.

TABLE III.—POWER CONSUMED IN HORSE-POWER

Trains No.	Section 1.	Section 2.	Section 3.
1 and 3	+658	+250	−635
2 and 4	−800	+250	+550
5, 7, 9, 11, 13	+565	+130	−500
6, 8, 10, 12, 14	−515	+130	+455
15 and 17 .. .	+500	+71	−344
16 and 18	−434	+71	+420

TABLE IV.—POWER CONSUMED IN KILOWATTS.

Trains No.	Section 1.	Section 2.	Section 3.
1 and 3	+605	+230	−582
2 and 4	−736	+230	+505
5, 7, 9, 11, 13	+520	+120	−458
6, 8, 10, 12, 14	−472	+120	+420
15 and 17	+460	+65	−316
16 and 18	−400	+65	+385

In Fig. 1 curve *a* gives the course of all the trains in each direction; curve *b* is the total power consumed at every instant, assuming all the free energy in the grades to be consumed by friction brakes; curve *c* is the power consumed where recuperation in the grades is assumed; curve *d* is the actual quantity required in this case at the central station (not including line loss). In curves *b* and *d* the dotted lines show the average value of power for a given working time. It will be seen that these average quantities are respectively 480kw. without recuperation and 230kw. with recuperation. Even if there be added in the latter case 60 per cent. of the maximum quantity of power for line loss, the series system with regeneration will still offer a slight advantage.

A short tramway line supplied with constant direct current has been working for the past few years at Northfleet, near London, but the system adopted for feeding the car-motors in series is too expensive and not strong enough to be used for railway work. The line forms a closed loop, one branch of which is divided into short sections by switches, which the car opens automatically to introduce its motors in the circuit.

The ingenious contrivance of Mr. Potterat consists in placing alongside of the two trolley lines, divided in sections, a third continuous line, each section of which contains an automatic switch. This switch, which is shown in Fig. 2, is worked by a magnet fed by the current of the train passing over the section. Details of the automatic switch are shown in Fig. 3. It may be applied to a single track over which trains run in both directions. The two trolley lines *t*, *t'* are connected to the auxiliary conductor *c* by means of the commutator coils. The coils 1 and 3 draw the core upward, while the coils 2 and 4 have a downward movement.

When the first section is free no current exists in the commutator circuits, the con-

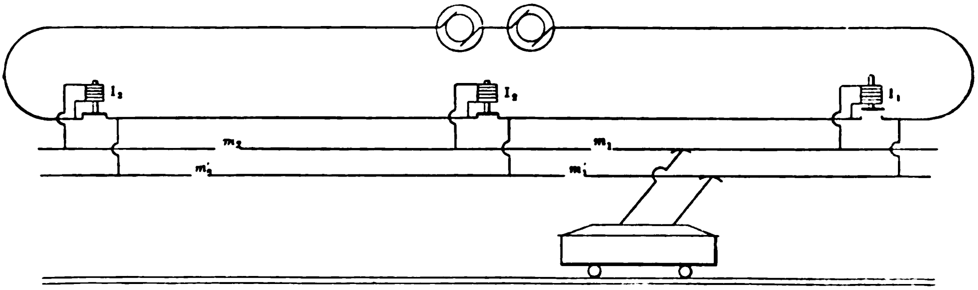


FIG. 2. ARRANGEMENT OF TROLLEY WIRES.

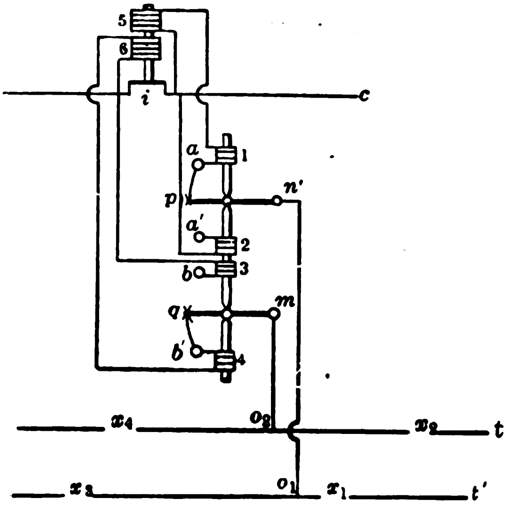


FIG 3. CONNECTIONS OF AUTOMATIC SWITCH.

tacts of which are in 1 and 4. If a locomotive runs to the left, its trolley passing on *t*, reaches the point of section x_2, and the current coming from t' through the motors, flows in coil 4, which attracts the cores downward, producing currents in $n\ a'$ and $m\ b'$, while the current in coil 6 has the effect of opening the switch *i* in lifting its core. As soon as the second trolley reaches the point of section x_1 the current flows through the circuit $o_1 n'\ a'\ c$ of the automatic switch in section $x_1 x_3$, and the result is that the switch of the last section—that is to say, the section before $x_1 x_3$—falls and renews the connection of the auxiliary line. When the second trolley of the locomotive leaves the section $x_1 x_3$ the apparatus resumes its first position and is ready for work again.

When the locomotive comes into the section from left to right, the commutator works in the same way, but the cores are now attracted upward and the contacts are made in ***m b*** and ***n a***. In the case of a sidetrack, four trolley lines will be cut at the points of junction. A second commutator will be placed beside the one on the first line, and the coils will be connected with the two trolley lines of the new track.

In these different workings the switches are opened when the current flowing through them has been sent in another road. The contacts, therefore, are not liable to deteriorate, and, if necessary, the commutator may be operated by hand.

The e.m.f. existing between the two trolley lines depends on the traffic, on the number of the locomotives running simultaneously, and on the voltage adopted for each motor. Mr. Potterat, in the case of the Montrejoux-Tarbes line, adopted 10,000 volts between wires and placed the trolley lines outside of the tracks.

It is known that in the series system with constant current the regulation at the generating station is controlled by the e.m.f., which varies with the load. In the series system the trolley lines are under voltage during only the running time of a train, and the e.m.f. between the wires is not the same as that of the generating station. The result is that the setting up of the trolley lines in this system presents less difficulty than that of the three-phase system with constant e.m.f.

It is not necessary here to go into the question of the suspension of lines, as it offers nothing of special interest. The system may be modified as required. It is well simply to call attention to the fact that the return of the current through the rails is cut off, and, consequently, the motor should be insulated from the truck. Mr. Potterat adopted for this purpose a motor with vertical axis set up in the box of the car and controlling the axle by the conical cog system, shown in Fig. 4. The insulation of the framework of the motor from the axle is assured by an insulated elastic coupling enclosed in a box containing insulating oil. Although the e.m.f. of the motor may not be very high, the insulating e.m.f. between the wire and the ground is generally high and should be taken into consideration.

As is well known, in order to set a motor running on a distribution in series it is only necessary to open a short-circuit switch. This is done without danger to the operator, without injuries to the apparatus, and without shock at the generating station. As the torque of the motor depends solely on the position of the brushes, the regulation of the torque and of the speed is obtained without rheostat by adjusting the brushes on the commutator. This greatly simplifies the arrangement of the locomotive circuits. Each motor requires one hand-operated short-circuiting switch, a crank for moving the brushes, and an automatic short-circuiting switch, which acts when the brushes reach the zero point to cut off the current as the machine stops; an automatic switch for each high-tension circuit; an automatic speed-limiting switch.

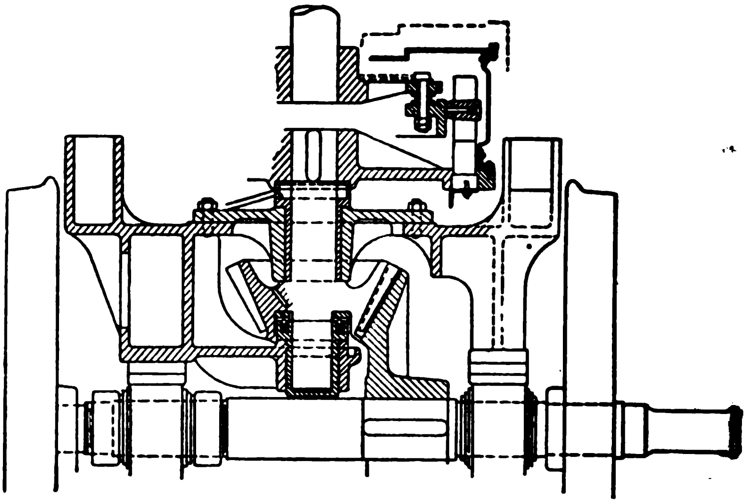


Fig. 4. The Motor Coupling.

The series distribution would be very inconvenient if all shunting had to be done in the station with the ordinary locomotives. But, as in the case of the steam engine, there is a tendency to use special small locomotives for this purpose, the same method may be resorted to in the case of electric traction, and this would do away with the distribution in stations, except for the principal tracks. In case of accident on the line, which must always be provided for, or, again, in the necessary shunting of big locomotives, Mr. Potterat suggests that each locomotive carry a 100h.p. gasoline motor-generator, which could supply directly the necessary current to produce a reduced speed of the locomotive.

Finally, a very important advantage was pointed out in the case of trolley lines covered with a coating of ice or frost. The constant current would cause this coating to melt, and the chances of interruption in service are, therefore, reduced to a minimum. On the contrary, with the constant-potential system, the coating of ice may be sufficient to suppress the feeding of the motor and to stop the trains. As a matter of information, there may be added hereto the statements prepared by Mr. Bourdel in order to make a financial comparison between the single-phase and the series system :

	One-Wire Line.	Two-Wire Line.
Posts (53 per mile)	£215	£270
Trolley wire ½-in. in diameter (per mile)	150	300
Setting up (per mile)	70	140
Bonding of rails	70	...
	£505	£710

If account be taken of the cost of setting up and the running expenses, one cannot but conclude that from the standpoint of economy, the series system might compare very favourably with the constant-voltage system.

FRICTION REDUCING BEARINGS.*

THE status of the friction reducing, or what we might term rotative, bearing, from an economical standpoint, is at the present time universally acknowledged, and can no longer be omitted by the progressive engineer or manufacturer in the design or purchase of any article requiring in its operation the expenditure of either power or labour.

In considering the particular type of bearing to be adopted, care should be taken to examine fully the advantages or disadvantages of the various designs, especially as regards the durability, efficiency, and practicability of each; in fact, a thorough study of the mechanical features involved will be of value, and will enable the designer or purchaser to select for himself that type of bearing best suited to his particular needs. In looking into the subject we find in general four distinct types: the conventional type of ball bearing; the ball bearing lacking principal conventional features; the solid roller bearing; and the flexible roller bearing. After looking into the respective merits and shortcomings of these various types, it will be useful to present a summary of the conclusions arrived at.

The Conventional Type of Ball Bearing.

Academically, the ball bearing offers the most perfect mechanical, or we may say geometrical, method of meeting and carrying stresses of various directions, and yet no known practical form of ball bearing actually provides equally well for all directions of probable stress thereon. Balls have been successfully used in bicycles, sewing machines, and numerous other constructions, and are to be recommended highly where the duty is light, and where the factor of safety is so ample as to protect shortcomings of design.

In any ball bearing the fact remains that the load must necessarily be carried upon a limited number of points of contact, and in those classes of heavier machinery where the saving of power is of great moment it has been found in practice that the academically-designed bearing will not support a load without distorting the balls or ball races. The results obtained by the conventional type of ball bearing presenting short radii of cone and case amply bear out this assertion.

The Solid Roller Bearing.

It would seem, therefore, that the logical step is to modify the construction so as to substitute for the limited number of points of contact in the ball, the line of contact given by a roller. The solid roller, on account of its rigidity, apparent from its construction, cannot in its practical operation in a bearing present contact along its entire length. It is impossible, therefore, to secure a uniform distribution of load, either on the face of the roller or on the surfaces on which it operates. The irregularities causing this lack of contact and inequality of pressure may be caused in various ways, such as slight deflections of the shaft, yielding of supports, or imperfections in the manufacture or mounting of the bearing. Such irregularities cannot be altogether eliminated, no matter what the conditions may be, and they tend to increase in cases where the bearings cannot receive great care, and where the work may be more or less crude. Such in general are

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* The above article contains much information regarding the practical performance of roller bearings, and forms a valuable continuation of the descriptive article, "Ball and Roller Bearings," which appeared in THE ELECTRICAL MAGAZINE AND ENGINEERING MONTHLY of September and October last.

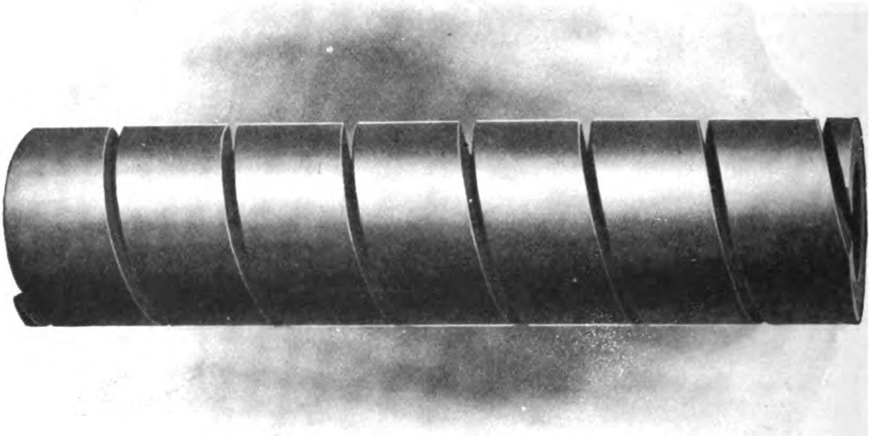


Fig. 1. The Hyatt Flexible Roller

the conditions under which the solid steel roller operates and which make it necessary not only to harden the roller, but to harden and grind all surfaces on which it runs. This has a tendency to complicate the construction as well as to increase the cost; it reduces, but does not eliminate, the objectionable features. With the solid roller, therefore, a complete line of contact on the maximum number of points is not necessarily secured, and if some method could be suggested whereby perfect contact and uniform distribution of load were effected along the entire length of the roller, better results would be obtained.

The Flexible Roller Bearing.

The distinctive feature of the Hyatt flexible roller bearing is the roller itself (Fig. 1), which is made from a strip of steel wound into a coil or spring of uniform diameter. The advantage of a roller of this construction lies in its flexibility, enabling it to present at all times a maximum bearing along its entire length, resulting in the uniform distribution of load on the roller and the surface on which it operates. The roller adjusts itself to all irregularities that may be present, and practice shows there is no necessity for hardening the various parts of the bearing, any soft steel surface satisfactorily answering all requirements. It will be seen as a further advantage of its construction that the roller acts as an oil reservoir, while the spiral and roller together perform the function of an oil carrier, thereby assuring perfect lubrication of all parts at all times, making it possible to operate the bearing for considerable periods without attention. Particular features of the Hyatt bearing are as follow:—

(1) It is applicable to all speeds and loads, due to ability to vary the nature of the rollers. Light, flexible rollers give a bearing suitable for light work; heavier and stiffer rollers meet conditions involving heavy duty at slow speed.

(2) The rollers in any case cannot crush, for they are designed to suit the particular load conditions with a proper factor of safety.

(3) The flexibility of the rollers ensures a maximum line of contact as compared with the small series of points secured with either solid rollers or balls; consequently a uniform distribution of load is obtained, and there is no tendency to distort the metal

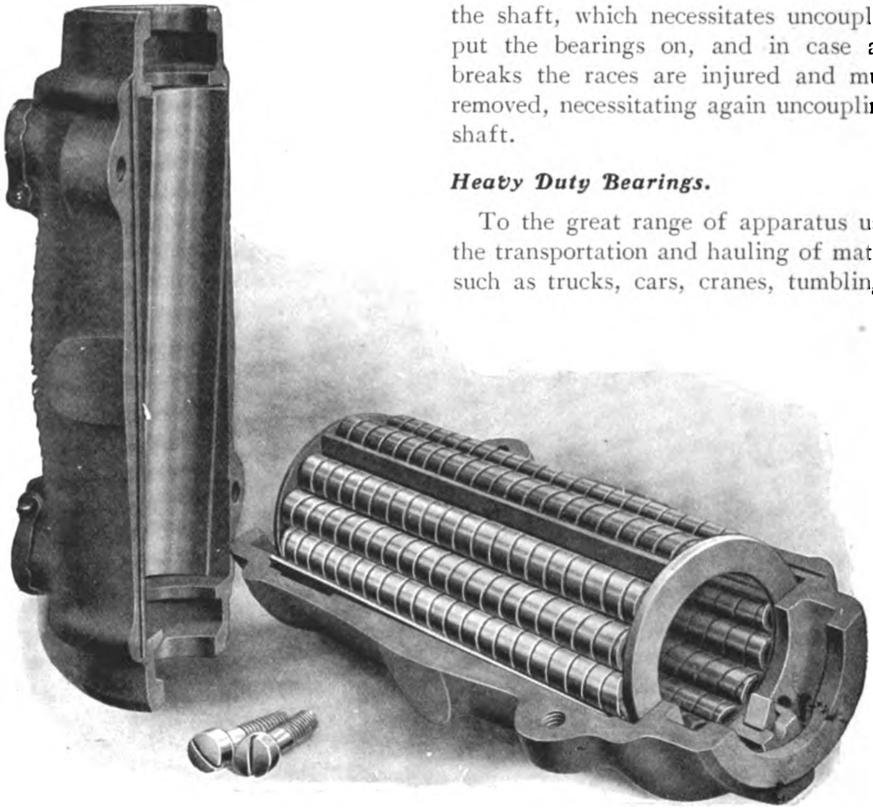


Fig. 2. Hyatt Improved Self-Oiling Shafting Box Partially Assembled.

of the journal or castings, eliminating the necessity of hardened and ground surfaces.

(4) The roller acts as a natural oil reservoir, while the right and left alternate spirals act as oil carriers and distributors.

(5) The roller has shown under tests to have a less coefficient of friction, hence higher efficiency, than any other design.

Bearings for Shafting.

There is a great advantage in the flexible roller bearing when applied to line shafting (Fig. 2) in that it is not necessary to prepare the shaft in any way with hardened sleeves, nor is it necessary to uncouple existing shafts to get the bearings in place, they being made in halves so as to be put on the same as any ordinary brass or gunmetal bearing. With a ball bearing it is necessary to slip races on over the ends of the shaft, which necessitates uncoupling to put the bearings on, and in case a ball breaks the races are injured and must be removed, necessitating again uncoupling the shaft.

Heavy Duty Bearings.

To the great range of apparatus used in the transportation and hauling of materials, such as trucks, cars, cranes, tumbling barrels, railway vehicles, &c., the flexible roller bearing gives satisfactory results. In such cases the saving of power seems to make the proposition an exceedingly attractive one, as it is found that from 20 per cent. to 50 per cent. can easily be saved on this class of application.

There is probably no one piece of machinery in a works which gives more trouble than a counter-shaft with a loose pulley on it. With flexible roller bushings in the hubs of the pulleys oiling is reduced to a minimum, and the pulley cannot possibly freeze fast to the shaft.

All high-speed machinery, such as pulverisers, fans, and apparatus of that character, can be operated on flexible roller bearings with very marked and satisfactory results, not only in the saving of power, but by obviating the frequent hot bearings,

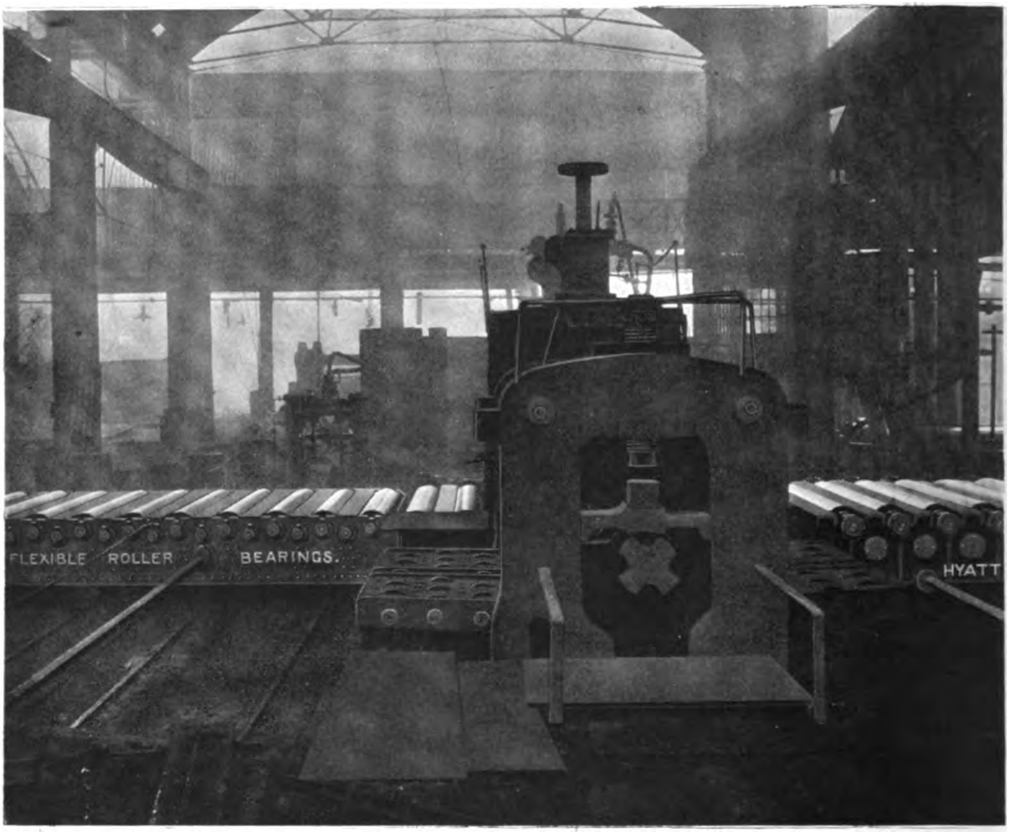


FIG. 3. HYATT BEARINGS AS APPLIED TO HEAVY ROLLER TABLE SERVING PLATE ROLLS. TABLE USES 50 PER CENT. LESS POWER SINCE THESE BEARINGS WERE FITTED.

which are so liable to occur with journals of the ordinary type.

Motor-car Service.

The flexible roller bearing has been found particularly suitable to the complex variety of speed and load encountered in the motor-car. It is stated that in America this year twenty-five different leading manufacturers, who together estimate that they will manufacture about 100,000 motor-cars, at low and moderate price, will use on these cars an average of from four to six bushings to a car, which means practically 500,000 flexible roller bushings to be applied in this direction only.

Power Economy.

Numerous tests have been made under all conditions of speed and load, and in every instance the results have justified the claim that roller bearings on line shafting will save from 10 per cent. to 25 per cent. of the power supplied. With this as a basis and figuring on the proper cost of power, it is shown that the extra cost of the roller bearing will be returned in the first year's operation by the saving of power alone.

The friction being so largely reduced by the substitution of rolling for rubber friction, the amount of lubricant is diminished in similar proportion. Actual tests have shown that 75 per cent. less oil is required with flexible roller bearings. Furthermore, friction being so largely eliminated and less power needed to perform the same work, less belting is required, or for the same amount of belting the life of the belts is correspondingly increased.

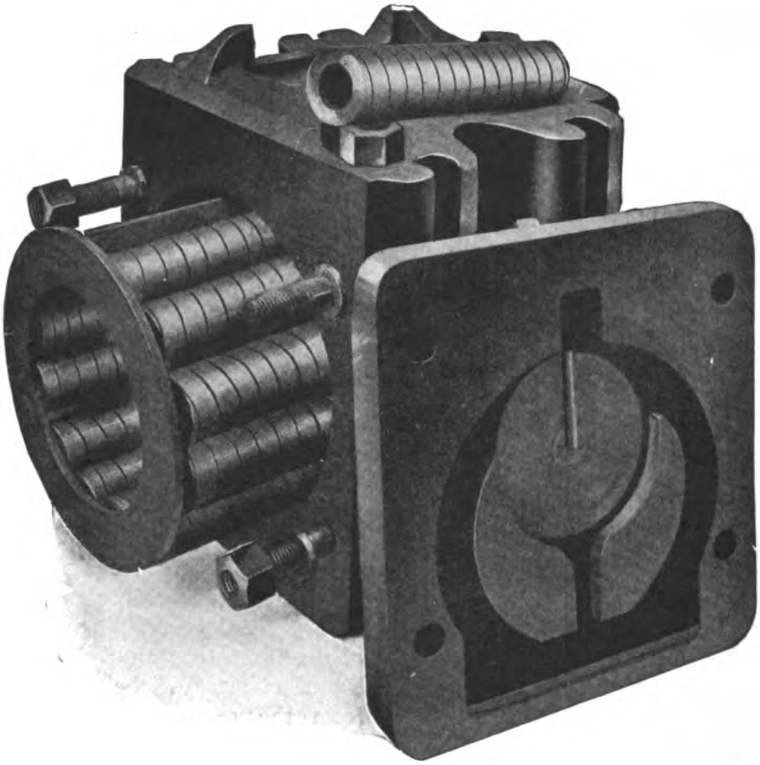


FIG. 4. HYATT BEARING FOR 20-TON COAL WAGON.

While in general the difficulty with hot bearings on line shafting might be considered negligible, on the other hand there are places in nearly every establishment where more or less annoyance, and in some instances enforced stoppage of work, is caused in this way. Roller bearings are applied with success in such instances where every other method has failed. An economy of 10 per cent. to 20 per cent. in power in many instances has enabled a smaller engine to accomplish the same results with marked decrease in outlay and fuel costs. In other cases the purchase of a larger engine has been avoided by the extra useful power made available by installing roller bearings in the works.

With electric drives it has been found possible to obtain the same results with a smaller motor, and by grouping several machines and operating them by a short line of shafting with roller bearings the most efficient of all methods of driving is secured.

Test Results.

The following test was made by the Committee on Science and Art at the Franklin Institute of Philadelphia, U.S.A. The test was made on four Hyatt spiral rollers, $\frac{3}{4}$in. in diameter by 10in. long, and four solid steel rollers of exactly the same dimensions. The flexible roller was made of a strip of steel $\frac{1}{2}$in. wide by $\frac{1}{8}$in. thick, and the solid rollers were made of a grade of steel of about 70,000lb. tensile strength.

These rollers were placed between three plates, as shown in the illustration Fig. 5, and the whole set placed between the plates of a testing machine, and vertical pressure applied. Whilst under this pressure a hori-

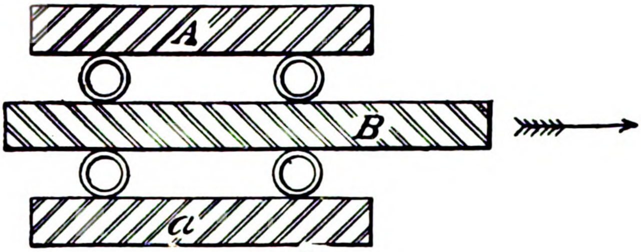


Fig. 5.

zontal force was applied to the middle plate, and the resistance to rolling accurately measured by its reaction on the platform of a scales. Increasing vertical pressures were applied up to a maximum of 550lb. per lineal inch of roller, when the apparatus employed would not permit a higher pressure, owing to the resistance to motion of the middle plate when solid rollers were employed; but under the same conditions with the spiral rollers it was possible to place a pressure per lineal inch of 700lb.

The condensed results of many trials show as follows:—

Total Pressure.	Resistance to motion of Middle Plate.
2000lb.	With Spiral Rollers 9lb.
2000 ,,	With Solid Rollers 26 ,,
3000 ,,	With Spiral Rollers 17 ,,
3000 ,,	With Solid Rollers 34 ,,

An interesting series of experiments has also been carried out with the object of determining the friction of roller bearings respectively with flexible and with solid rollers and plain cast iron bearings, also with white metal bearings under similar conditions. The results obtained are of some considerable interest.

Four sizes of bearings were used in the tests, measuring respectively 2in., 2¼in., 2½in., and 3in. in diameter. The lengths of journals were about four times the diameters. The bearings were in two parts, and were held in a circular yoke by set screws. This yoke carried two vertical spindles, one above and one below, on which were placed the weights for loading the bearings. The friction was measured either by the deflection of the compound pendulum thus formed, or by weighing its tendency to deflect by means of an attached cord running over a pulley and carrying a scale pan. The shafts or journals were of ordinary machinery steel and were rotated by means of a belt and pulley.

The cast-iron bearings used for comparison were cast whole and bored to size, but the white metal ones were in halves, and were held the same as the roller bearings.

In beginning an experiment, a pointer on the lower end of the pendulum was brought to a zero mark vertically beneath the centre of the shaft by adjusting the screws in the yoke. After the shaft began to revolve the pointer was held to the zero mark by putting weights on the scale pan. The product of the force thus applied to the pendulum by the distance of the point of application from the centre of the shaft gave the moment of friction, and dividing this by the radius of journal gave the friction at the surface of the journal. Dividing this again by the total weight on the journal gave the coefficient of friction.

In the first set of experiments Hyatt

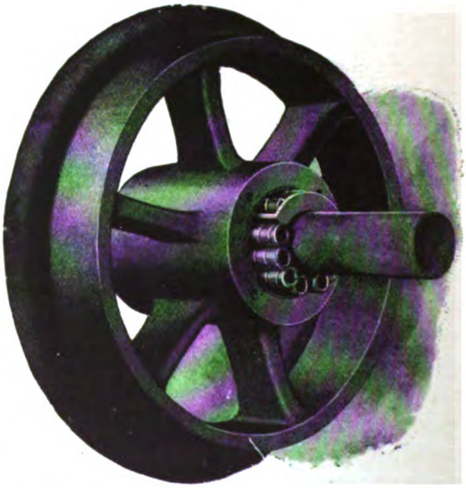


Fig. 6. Hyatt Mine Tub or Bogie Wheel.

flexible roller bearings were compared with plain cast iron sleeves at a uniform speed of 480 revolutions per minute, and under loads varying from 64lb. to 264lb. The cast iron bearings were thoroughly and copiously oiled, the lubrication being rather better than would be the case in ordinary practice.

Table I. shows the results of the test on one bearing in detail, and from this it is seen that the value of F, the coefficient of friction, diminishes as the load increases, or, in other words, the friction did not increase as fast as the load. This holds true as a general rule in all the roller bearings, but not generally in the plain bearings, either cast iron or white metal.

TABLE I.

JOURNAL TWO INCHES IN DIAMETER.

Total Load. lb.	Friction.		Values of F.	
	Hyatt.	Plain.	Hyatt.	Plain.
64.2	2.34	10.24	.036	.160
114.2	3.27	12.10	.029	.106
164.2	4.21	19.10	.026	.116
214.2	4.78	22.35	.022	.104
264.2	5.15	26.10	.019	.099
Average	—	—	.026	.117

Table II. gives a summary of this series of experiments for the different sizes of journals, the different loads being the same as in Table I.

The relatively high values of F in the 2¼in. and 3in. roller bearings were due to the snugness of the fit between the journal and the bearing, and show the advisability of an easy fit as in ordinary bearings.

The same Hyatt bearings were used in the second set of experiments, but were compared with the solid roller bearings and with plain white metal bearings freely oiled. (See Table III.) The solid roller bearings contained hardened rolls of solid steel and guided by spherical ends fitting recesses in cage rings at each end. The cage rings were joined to each other by steel rods parallel to the rollers.

TABLE II.

VALUES OF COEFFICIENT OF FRICTION, F.

Diameter of Journal.	Hyatt Flexible Bearing.			Plain Bearing.		
Inches.	Max.	Min.	Ave.	Max.	Min.	Ave.
2	.036	.019	.026	.160	.099	.117
2¼	.052	.034	.040	.129	.071	.094
2½	.041	.025	.030	.143	.076	.104
3	.053	.049	.051	.138	·091	.104

Table III. shows the detailed results of experiments on one size of journal, and is similar to Table I. The same apparatus was used as in the former tests, but heavier loads were used and the machine was run at a slightly higher speed. There is the same indication as in Table I. of a decrease of F with increase of load, and this was noticed in all tests.

The results for the white metal bearings are not as uniform as the others on account of the difficulty of balancing.

TABLE III.

JOURNAL TWO INCHES IN DIAMETER.

Total Load. lb.	Friction.			Value in F.		
	Hyatt.	Solid Roller.	Babbitt.	Hyatt.	Solid Roller.	Babbitt.
113.3	3.64	3.77	8.38	.032	.033	.074
162.3	3.77	4.24	8.97	.023	.026	.055
211.3	4.04	5.24	8.97	.019	.025	.042
260.3	4.31	5.37	8.97	.016	.021	.034
309.3	4.57	6.46	10.15	.015	.021	.033
358.3	4.71	6.73	10.75	.013	.019	.030
407.3	4.84	7.27	11.98	.012	.018	.029
Average	—	—	—	.0186	.023	.048

Under a load of 358.3lb. the solid roller bearing showed an end thrust of about 20lb.

Table IV. gives a summary of the tests in this series, and may be compared with Table II.

Under a load of 470lb. the solid roller bearing developed a thrust of 11lb. This is due to the slight skewing of the rolls, and would vary, sometimes even reversing. The flexible roller does not develop this fault. The white metal bearing is a slight improvement over the cast iron sleeve, but the difference is quite apt to be due to improved lubrication. (Notice the variation in the averages for the various sizes in Table IV.)

TABLE IV.

VALUES OF COEFFICIENT OF FRICTION, F.

Size of Bearing.	Hyatt Flexible.			Solid Roller.			Babbitt.		
Inches.	Max.	Min.	Ave.	Max.	Min.	Ave.	Max.	Min.	Ave.
2	.032	.012	.018	.033	.017	.022	.074	.029	.043
2¼	.019	.011	.014	—	—	—	.088	.078	.082
2½	—	—	—	.028	.015	.021	.114	.083	.096
3	.029	.022	.025	.039	.019	.027	.125	.089	.107
General	averages		.019			·0233			.082

The difference in F between the Hyatt flexible and the ordinary solid roller is .0043—that is, the friction of the flexible roller is 23 per cent. less than that of the solid roller. The difference between the roller and plain bearings is too obvious to need explanation.

It may be said that the friction of the roller bearing is shown to be from one-fifth to one-third that of a plain bearing. It is also noticeable that as the load on a roller bearing increases, the coefficient of friction decreases.

In the solid roller bearing the rolls bore on a cast iron sleeve, and in the Hyatt on a soft steel one. If roller bearings are properly adjusted and not overloaded, a saving of from two-thirds to three-fourths of the friction may be reasonably expected, and there is no danger of the flexible rollers wearing the shaft, while the solid ones showed a tendency to do so.

The following test was made by Professor G. F. Charnock, of the Bradford Technical College. Fig. 9 shows the apparatus which was used for this test.

From the results plotted in Fig. 10 it will be seen that the bearings used in this test were for 2¼in. shaft by 9½in. long, the average coefficient of friction for the flexible roller bearing being .01007, whereas the average coefficient of friction for the plain bearing was .03085, being about three times that of the flexible roller bearing.

Another working test on line shafting was made at the works of the British Case Makers, Ltd., of North Shields. This line of shafting was carried on seven 3in. and four 2in. bearings. Before the application of the flexible roller bearing, an average consumption of electric power over a period of six weeks was carefully taken, and found to be 935 units per week. After the flexible roller bearings were fixed a similar average reading was taken over a period of four weeks, and it was found that the consumption was 595 units per week, the difference in favour of the flexible bearings being 340 units. The price paid for electric power at this place is 1⅛d. per unit, which equals £1 11s. 10½d. actually saved each week by the flexible roller bearings.

The total cost of these bearings for this equipment was less than £25, therefore the bearings paid for themselves in four months.

A testing apparatus for showing the difference between flexible roller and ring oiling bearings, as used by Messrs. Schuchardt and Schutte, in Vienna, is shown on page 365. It will be easily seen that the arrangement consists of two sets, one fitted up with four of the best ball and socket ring oiling type bearings to be found, and the other set is made up with four standard Hyatt ball and socket flexible roller bearing pillow blocks. A short piece of shaft is carried in two bearings in each case, and the other two bearings in between are inverted and carried on a frame across which rests a lever in each case, one end of the lever being made fast with hinge joint,

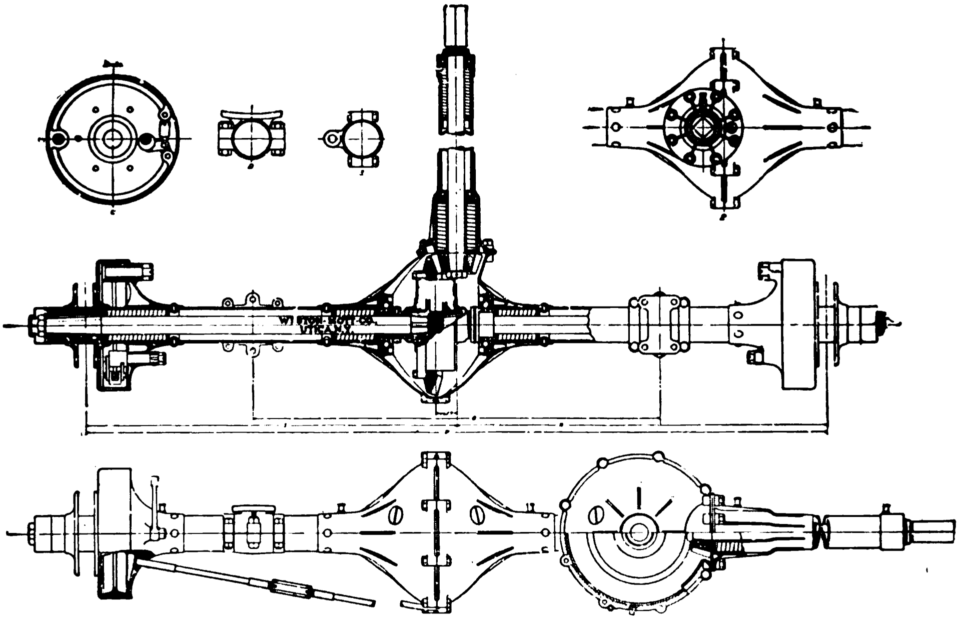


FIG. 7. SHAFT-DRIVEN REAR AXLE AND PINION SHAFT, EQUIPPED WITH HYATT BEARINGS THROUGHOUT.

and the weight is movable along the measured portion of the length of the lever.

The test as given below was made with the weight placed in position to exert a pressure of 1400lb. on the shaft. This is somewhat in excess of the ordinary shafting practice. The electric motor which drives the sets is wired up to a watt-meter, and the belting from the counter-shaft, as shown, is arranged so that the sets may be driven individually, the belt of one being thrown off while the other is being worked or driven.

In this way the exact power is measured on the watt-meter, showing precisely the amount of power which is required in each case, and it was shown that with the roller bearing there is an increased efficiency, or in other words a decreased consumption of current amounting to over 20 per cent. The actual test figures were :—

Load on the lever, 1400lb. ; shaft, 2in. in diameter ; 320r.p.m.

Motor driving counter-shaft only, 750 watts.

Motor driving roller bearing apparatus, 800 watts.

Motor driving ring oiling apparatus, 975 watts.

Difference between the roller and ring oiling bearings being 175 watts, which represents an increased efficiency of the Hyatt bearing over the ring oiler of 21.8 per cent.

We have presented several laboratory tests in detail, and perhaps some practical tests under actual working conditions would also be of some interest.

A test of some considerable importance was made at one of the departments of the United Shoe Machinery Company. The line shaft which was tested was 152ft. long, supported by 20 bearings, and the diameter of the shaft was 3in. It was belt driven at one end from a head shaft ; belted from the line shafting are counter-shafts of 88 machine tools, and it will be noticed in the results that only a small part of the friction load is caused by the main shaft itself.

The summary of results is as follows :—

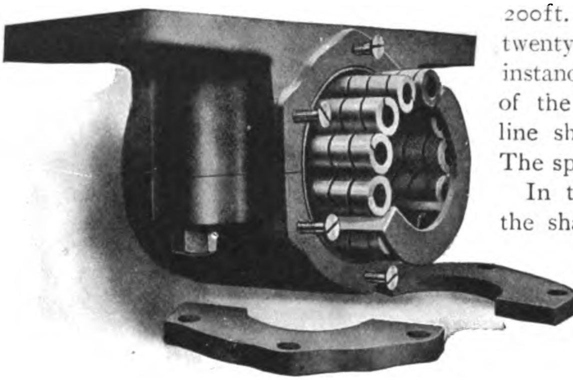


FIG. 8. HYATT BEARING FOR MINE TUB OR BOGIE. END PLATE REMOVED.

Average friction load, 88 counters constantly running:

Main shaft in white metal bearings, 8.85h.p.
Main shaft in flexible roller bearings, 6.36h.p.
Percentage of saving by flexible roller bearings, $16\frac{7}{10}$ per cent.

Average friction load on main shaft only, all counter belts thrown off:

White metal bearings, 2.28h.p.
Flexible roller bearings, .80h.p.
Percentage of saving by flexible roller bearings, $64\frac{9}{10}$ per cent.

Another test was made in a large railway works, with a view of obtaining not only the frictional load on their line shafting, but the power required to drive the various machine tools, which were driven in groups by various motors.

All measurements were made by means of a voltmeter and an ammeter in the motor circuit. It is stated that a line of shafting in this works 200ft. long, with belts thrown off, could easily be turned by hand, but in spite of the unusual efficiency of the bearings on this shafting it was noticed that the power consumed by many of the machine tools is often less than that lost in transmission.

In the wheel section of these works the shafting was driven by a 40h.p. motor, which operated twenty-three machine tools. The line shaft driving this lot of tools is 200ft. long, 2½in. in diameter, and has twenty-six bearings. In this particular instance it was inconvenient to obtain a test of the line shaft alone, but a test of the line shaft and counters only gave 1.5h.p. The speed of the shaft was 160r.p.m.

In the boiler section of the same works the shafting was driven by a 30h.p. motor, operating twenty-five machines. All counter belts were thrown off, and the line shafting tested alone. The same running on flexible roller bearings showed a result of .3h.p. only. This shaft is 170ft. long, 2½in. in diameter, and runs in nineteen bearings. The speed of the shaft was 158r.p.m. A test of the same shaft with counter-shaft running gave an average of only 2h.p.

In another works the results obtained by substituting for plain bearings thirty flexible roller bearings on overhead line shafting were sufficient to avoid the purchase of a larger motor. The conditions were as follow:—

White metal bearings, including loose pulleys, and motor losses, 224 volts, 36 amperes = 8064 watts.
Flexible roller bearings, under same conditions, 222 volts, 30 amperes = 6660 watts.
The motor running free, 223 volts, 4 amperes = 892 watts.
The rated capacity of the motor was 15h.p.

The saving shown is as follows:—

Power saved by flexible roller bearings, $17\frac{4}{10}$ per cent.
Indicated horse-power saved by the flexible roller bearings, 2.4h.p.

Commercially applied, we have the following deductions:—

Approximate cost of 30 2in. flexible roller bearings, including fixing—£30.
Net profit on investment after paying interest and depreciation—28 per cent.
Time required for saving to repay investment—2⅓ years.
Time required, assuming flexible roller bearings had been originally fixed—1¼ years.

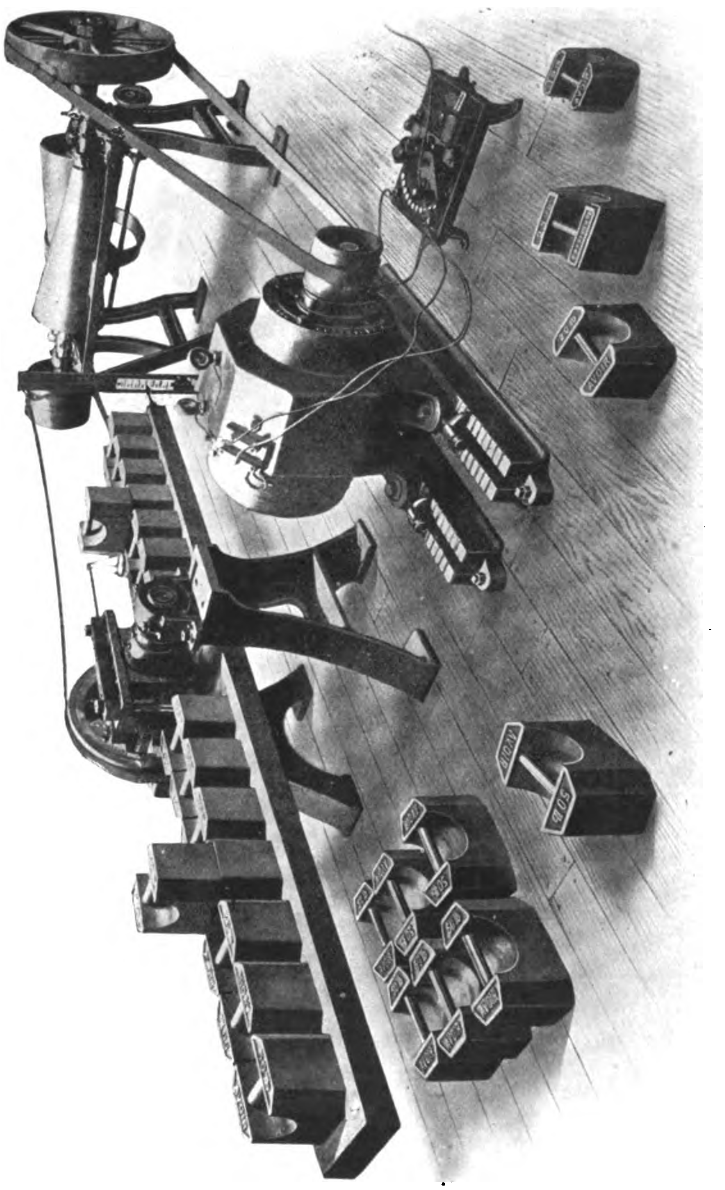


Fig. 9. Test Apparatus used by Professor G. F. Charnock, of Bradford Technical College.

Interesting results were obtained by a large firm of crane builders from a test they made to determine the difference between the efficiency of flexible roller and bronze bearings.

The bearings were used in a bridge truck wheel of a 15-ton crane, and the test shows the power used, first with wheels equipped with bronze bearings and afterwards with wheels equipped with flexible roller bearings.

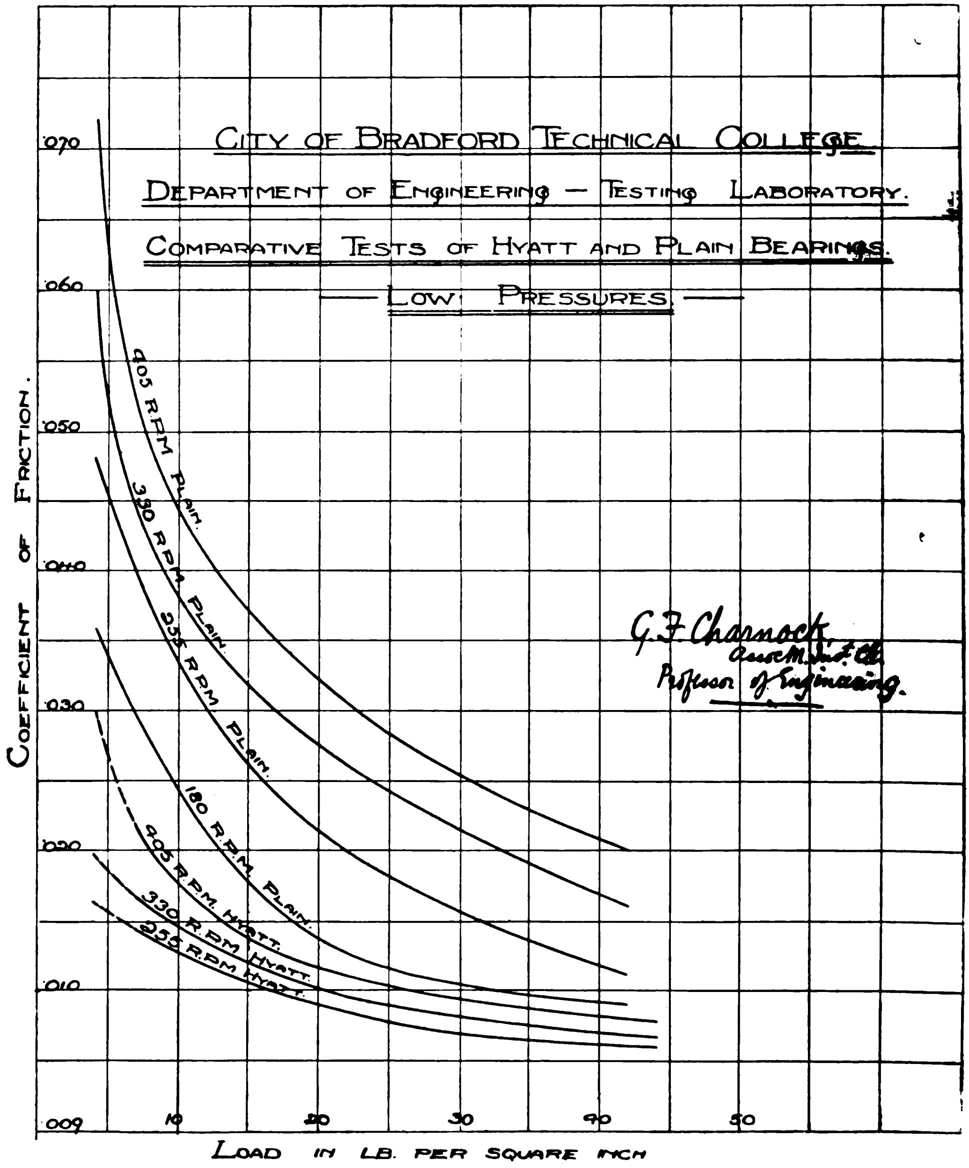


Fig. 10.

The weight of the crane without its load was 34,000lb.

Weight of the load 28,000lb, making a total of 62,000lb.

Diameter of truck wheels 21in., diameter of pin or axle $3\frac{1}{2}$in.: 15 h.p. motor at 220 volts.

Bronze Bearings.—With no load on the hook—18 amperes: 40lb. torque: $5\frac{2}{10}$ b.h.p. 340r.p.m. for the crane. With 28,000lb. on the hook—30 amperes: 80lb. torque: 8b.h.p. 265r.p.m. of the crane wheels.

Flexible Roller Bushings.—With no load on the hook—16 amperes: 32lb. torque: $4\frac{6}{10}$ b.h.p. 356r.p.m. of the crane wheels.

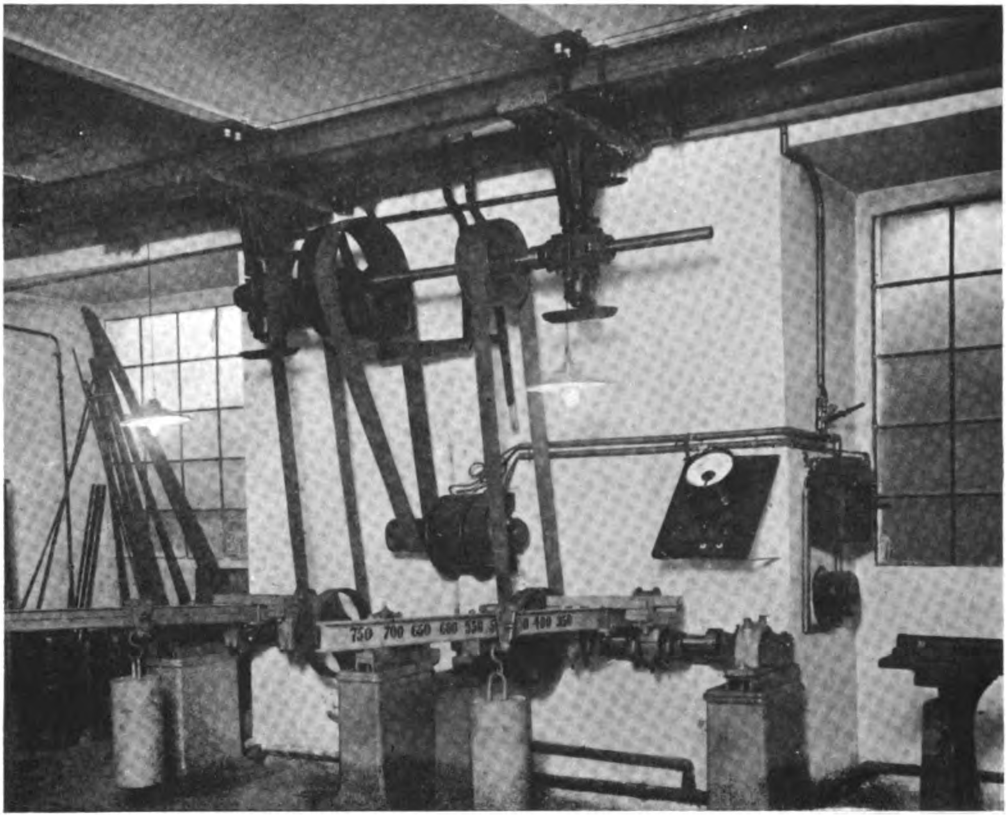


FIG. 11. APPARATUS FOR TESTING THE RELATIVE EFFICIENCY OF HYATT BEARINGS AND STANDARD RING OILING BEARINGS.

With 28,000lb. on the hook—22½ amperes: 56lb. torque: $6\frac{4}{10}$ b.h.p. 305r.p.m. of the crane wheels.

From the above we get the following deductions:—

Percentage of power required for full load with flexible roller bearings as compared with the bronze bearings:—

Torque, 70 per cent.; b.h.p., 80 per cent.; increase in speed of crane, 80 per cent.; b.h.p. for equivalent speed, 69½ per cent.

Tests on Railway Rolling Stock.

In a series of tests made on railway rolling stock, it was found that the coefficient of starting friction for brass bearings under loads on each bearing up to 6000lb. averaged about 14 per cent., while the frictional resistance of the flexible roller bearings was about one-quarter of one per cent. In other words, the frictional resistance at starting with brass bearings is fifty-six times as much as for the flexible roller bearings.

The coefficient of friction for brass bearings was found to vary widely in its limits both with load and speed, while the frictional resistance of the flexible roller bearings was constant.

With an average load of 3500lb. on each bearing the power spent on brass bearings in getting up the speed of fifteen miles per hour would be about twenty-two times as much as on flexible roller bearings, considering frictional resistance only; or, taking into account the power required to accelerate

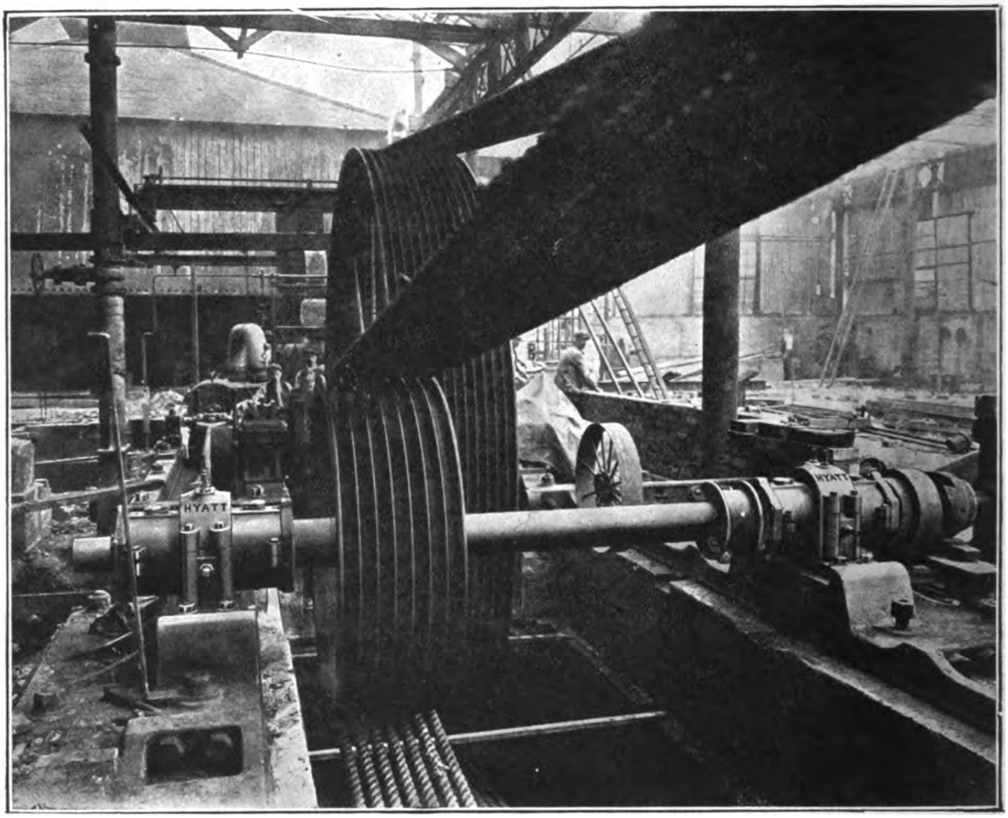


FIG. 12. 7IN. HYATT BALL AND SOCKET PLUMMER BLOCKS, ON ROLLING MILL SHAFT RUNNING AT 400 R.P.M.

the car, as well as to overcome the frictional resistance, from one-half to twice as much power will be required to get up the speed with a car on brass bearings as on flexible roller bearings under ordinary conditions.

The following table shows the horse-power required to operate an ordinary railway wagon where the load upon four wheels or journals was 11,000lb.

Speed, miles per hour.	H.P. required with Brass Bearings.	H.P. required with Roller Bearings.
10	1.65	.15
10	1.65	.15
20	.90	.30
30	1.00	.40
45	.75	.55
60	1.25	.65

In a series of tests on electrically-driven trams, it was found that the actual saving in power amounted to about 50 per cent. when flexible roller bearings were used in place of the ordinary brasses, and it was further found in another test that they could save from 12 per cent. to 15 per cent. of the fuel when roller bearings were employed.

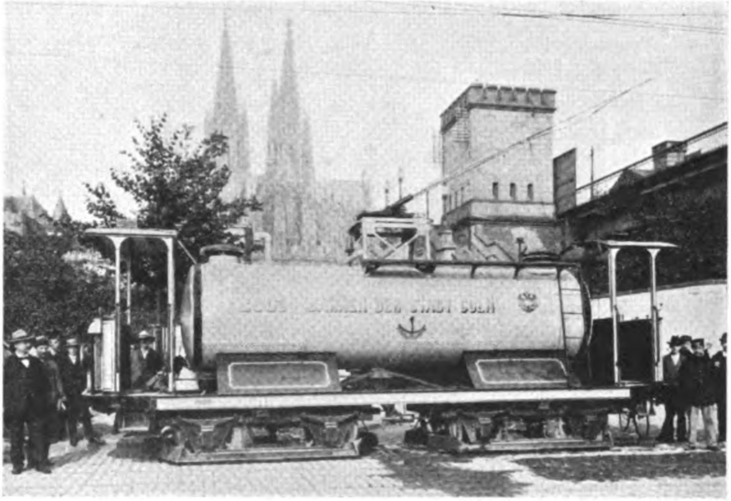
Another test made at a large colliery where a light railway was in use, and the cars were drawn up an incline by means of electric motors, showed that while the motor could pull up only six cars on ordinary bearings, with the same current, and other conditions being the same, the motor could draw eight cars after they had been fitted with Hyatt bearings, making a net saving of about 33⅓ per cent.

THE WORLD'S PROGRESS IN ELECTRICAL AND GENERAL ENGINEERING.

A Large Electric Sprinkling Car.

THE general construction of a large electrically-driven sprinkling car of the tramways system of the city of Cologne is shown in the accompanying illustration. This car has a total weight of 13 tons empty, and when filled with water and ready for operation weighs 23 tons. It is provided with double trucks and two direct-current electric motors operating at a pressure of 500 volts, and each having a capacity of 35 horse power. The nozzles throw the water spray a distance of about three yards, and a rotary pump is utilised for discharging the water under pressure. The pump is directly driven by a four horse-power shunt wound 500 volt electric motor.

The tank, which holds 13 cubic yards of water, is filled at the various hydrants of the city waterworks system, and it requires about ten minutes entirely to fill the tank by means of two pipes, each 1.8in. in diameter. The tank, when full, will sprinkle an area of 600,000 square yards, the car operating at a speed of 7½ miles an hour. The cost of operation of this motor sprinkling car is said to be about 16s. per day, while it would require five small sprinkling cars, each having a capacity of less than three cubic yards, when hauled by horses to do the same work as the electric car shown in the illustration. The cost of operating each of the small sprinklers hauled by horses is said to be 8s. per day, or a total of 40s. for the five sprinklers. Thus it would seem that there is a saving of 24s. per day by using the electric sprinkler—or say £120 per 100 working days. Each of the small horse-drawn sprinklers would cover an area of less than 100,000 square yards per day, while the electrically-operated sprinkling car, as said, will easily cover an area of from 600,000 to 700,000 square yards.


SPRINKLING CAR OF THE COLOGNE TRAMWAYS.

❧

Heavy Motors for Wood-Pulp Grinding.

THE manufacture of wood-pulp and paper is one of the most important industries of Austria. Until recently the practice has been to erect grinding mills adjacent to the forests, taking advantage for power of the many waterfalls which abound in the neighbourhood, and saving the heavy and cumbersome transport of the timber baulks to the finishing mills. The result of this system was that the raw material left the forest neighbourhood in the form of roughly prepared and dried pulp-board, which had to be again broken up and wet-ground at the mill to put it into marketable form. Thus there was the expense of duplicating one stage of the manufacturing process. This expense is now avoided in many cases by the use of electric power. The long-distance high-tension transmission systems afford a means of bringing heavy powers right into the paper mills, and as a consequence the pulp grinding, refining, and paper making are carried out at one centre without interruption of process and with maximum economy in power and labour.

A noteworthy plant of this description, and typical of the many which are now in operation in Austria, is that of Iqnaz Spiro & Sons, Kruman, put down by the Austrian Siemens-Schuckert Company.

In this plant, the grinder produces wood pulp for the manufacture of printing paper. From ten to twelve tons of wood pulp are produced every twenty-four hours. The stone is 4ft. 6in. in diameter, and makes 246 revolutions a minute. The press cylinders are connected to a conduit, fed with water under pressure by a pump, and of a size allowing beams one yard long to be inserted into the press casings. These beams are pressed automatically against the stone. The feed of the beams is effected automatically by an electrical regulator, ensuring a uniform load on the various presses. The stone can be dressed during operation by means of a special machine.

The grinder is direct coupled through a flexible coupling to a 750h.p., three-phase slip-ring motor. The motor operates at 500 volts, 42 periods, and is supplied through a transformer, the primary of which is connected to a 15,000 volt transmission line.

The motor was specially designed for continued operation for days and weeks at full load, so that no intervals for cooling could be relied on. Without resorting to any artificial cooling by special ventilating fans or blowers, the dimensions of the motor were so chosen as to avoid any excessive heating in any one of its parts, by causing the air current produced by the rotating armature to ventilate all the live parts. The stationary part consists of a cast-iron casing having a number of ventilating openings, and two substantial feet, by which the stator rests on the foundation beams. The active iron body of the stator is made up of annealed special sheets with coils distributed round its circumference, and it is freely suspended in the cast-iron casing by a number of fixed points, so that all parts are air-surrounded.

The rotor comprises a double-arm system, and is fitted to the steel shaft by means of two shrink rings and a wedge. The core of the rotor, having coils in closed slots, is also designed to be as well ventilated as possible so that no accumulation of heat may occur.

Before delivery the motor was submitted to thorough tests, showing an efficiency of over 92 per cent. at full load, and an overload capacity up to 1300h.p. The installation has now been in operation for several months, and is proving successful in every respect.

⁂

"The Simplex" List.

Many of us are inclined to associate the name "Simplex" only with conduits. How fallacious this is is indicated by the handsome catalogue just published by Simplex Conduits, Ltd. The 374-page book, strongly bound in cloth boards, printed in colours on art paper and with several hundreds of high-class illustrations, tells that this firm is good to supply anything required by the wiring contractor or the electricity user, whether his interest be as a tradesman or whether he needs heating, lighting, or cooking appliances for the home. Every class of electric fitting is listed, from the low-priced plain types for the small house to the most gorgeous and expensive for the mansion. As a practical guide to the purchaser of electrical details it leaves nothing to be desired.

Standardising Electric Motors for Machine Tool Service.

At the annual convention of the American Machine Tool Builders' Association, held in New York in October last, a preliminary report of the committee on standardising electric motors as applied to machine tools was presented. It appears that American motor manufacturers are contemplating the production of a new class of motors to be known as machine-tool motors, and a conference has been held between the committee and the Motor Manufacturers' Association.

PROPOSED STANDARD SPEEDS OF VARIABLE SPEED MOTORS.

H.P.	Maximum Speed.	RANGE.			
		4 to 1	3 to 1	2 to 1	1½ to 1
1	2200	550	740	1100	1480
2	2200	550	740	1100	1480
1	1800	450	600	900	1200
2	1800	450	600	900	1200
3	1800	450	600	900	1200
5	1800	450	600	900	1200
7½	1800	450	600	900	1200
10	1800	450	600	900	1200
2	1500	375	500	750	1000
3	1500	375	500	750	1000
5	1500	375	500	750	1000
7½	1500	375	500	750	1000
10	1500	375	500	750	1000
15	1500	375	500	750	1000
15	1200	300	400	600	800
20	1200	300	400	600	800
25	1200	300	400	600	800
30	1200	300	400	600	800
20	900	225	300	450	600
25	900	225	300	450	600
30	900	225	300	450	600
40	900	225	300	450	600
30	720	180	240	360	480
40	720	180	240	360	480
50	720	180	240	360	480

The points on which it is aimed to bring about uniformity are base and bolt-hole dimensions and locations, tolerances, shaft diameters, maximum speed of motors and peripheral speed of gears, the question of speed being the one which has given the most trouble. The report contains a preliminary table of maximum and minimum speeds of variable-speed motors having a range from 1½ to 1 up to 4 to 1. The table is given in the preceding column.

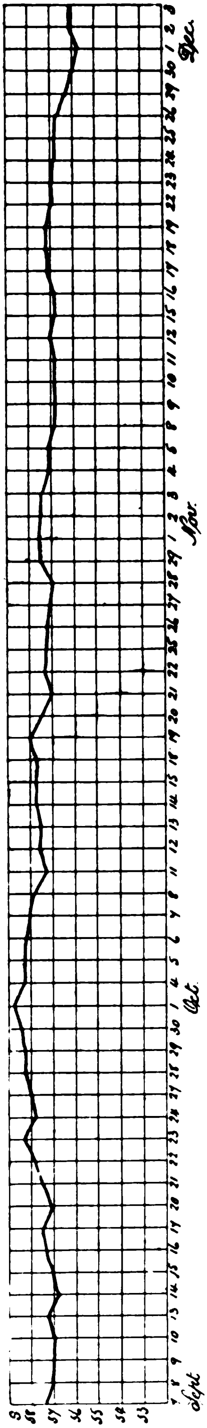
The report brought out a very animated discussion, the general nature of which was an expression of dissatisfaction, the chief point criticised being the upper speed limits, which, in the opinion of many, were much too high for connection by gears.

The situation when the subject was under discussion by a previous committee was pointedly referred to, this situation being a general desire on the part of motor manufacturers that the machines be standardised, but with the feeling in each case that the construction of each manufacturer was the proper standard for all to adopt. At present this condition exists in a much less degree, if it exists at all, motor manufacturers through their association having become convinced of the advantages of standardisation, and they now desire to bring it about by co-operation.

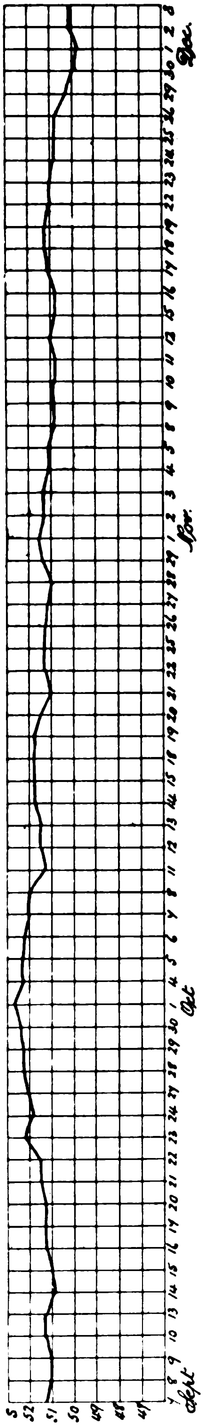
The report was finally referred back to the committee without specific recommendation, although the points raised in the discussion can scarcely fail to be taken into consideration and be reflected in the final report. It may be fairly stated that the outlook for standardising the essential features of motors for machine tools, with the consequent avoidance of annoyance and unnecessary expense, is at least reasonably bright, and in view of the burden which this annoyance and expense has been to machine-tool makers in the past, this outcome, should it follow, will alone go far to justify the existence of the association.

Home Market Metal Prices for the Past Three Months.

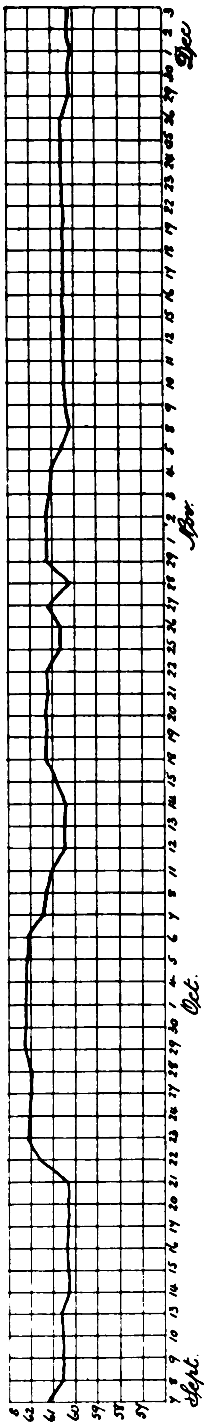
Iron: Scotch.



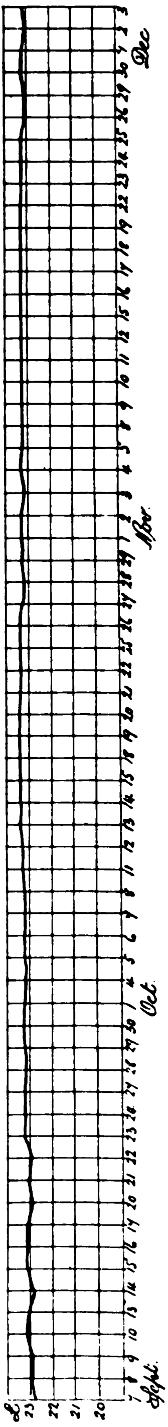
Iron: Cleveland.

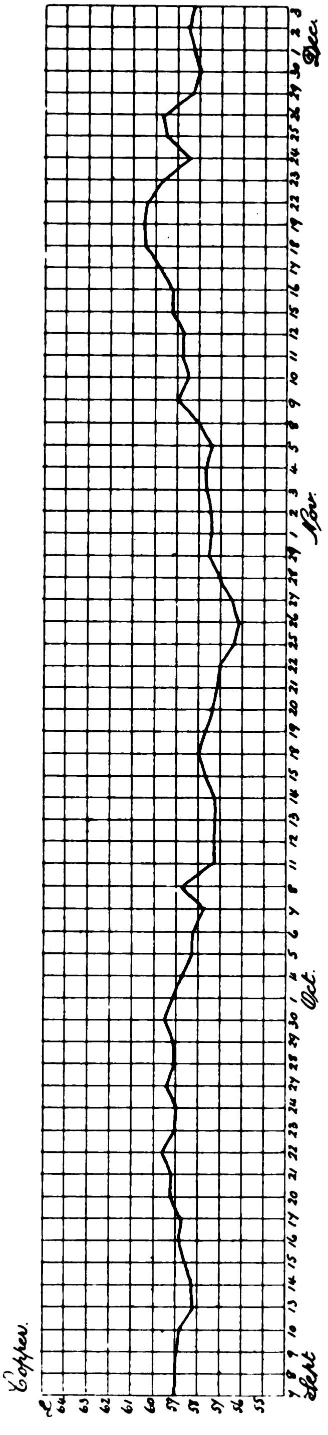


Iron: Hematite.



Spelter.

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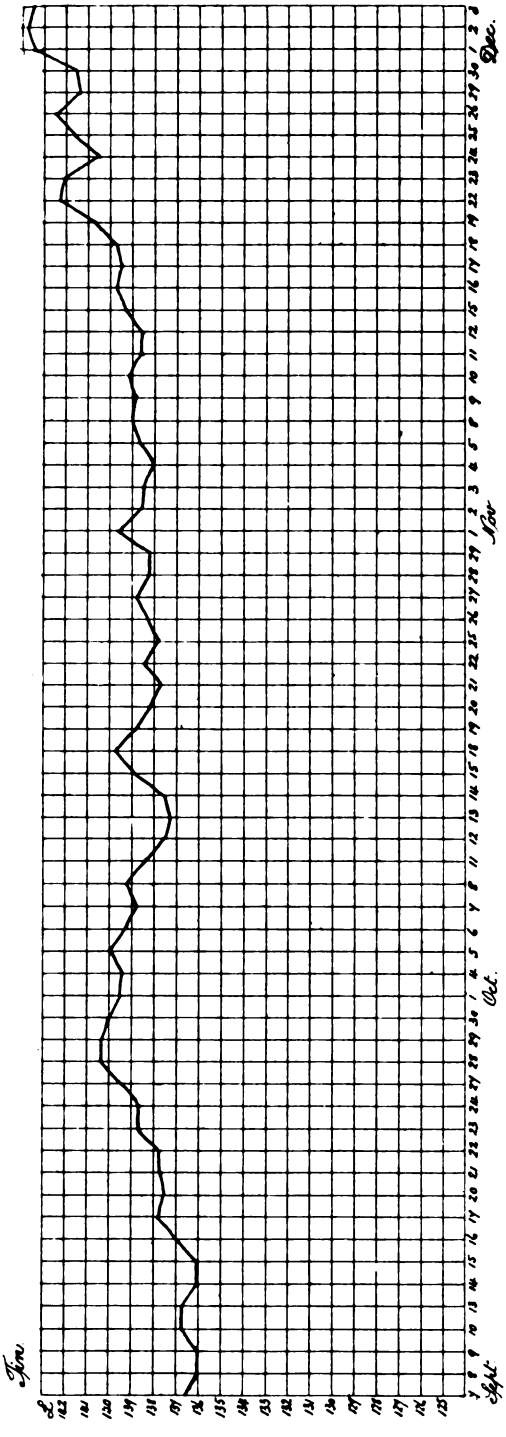
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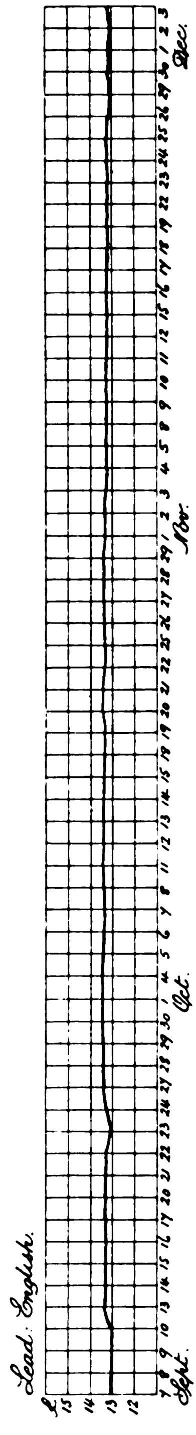
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Cotton-mill Engineering.

THE third edition of the well-known text-book, "Recent Cotton-Mill Construction and Engineering," has just been published by John Heywood, Ltd., Manchester. Originally compiled by the late Joseph Nasmith, the work of producing the third edition has devolved upon his son, Mr. Frank Nasmith. Considering the remarkable progress which each of the past few years has witnessed in building construction, as dictated by increased knowledge of fire-prevention, hygienic conditions, and general efficiency and economy of materials; also the rapid strides taken in methods of power-driving, lighting, and in the many improvements made in productive machinery whereby speed and uniformity of output have reached almost a penultimate stage—there is little wonder that the author has found it necessary to practically produce a new work, or, at all events, to rewrite the original almost from cover to cover. This he has done, and in consequence the publication can more than ever claim to be the standard text-book of its subject. It is doubtful whether there is, indeed, any other publication of this character which covers the ground so well and completely.

The volume contains some 400 pages of matter, including 197 illustrations and 33 tables, all of which are indexed. There is also the feature of a carefully-compiled general index, which is indispensable to any text-book which has pretensions to perfection. As indicating the scope of the book, and because it is practically impossible to review such a general treatise in detail, it will be well to give the subject-headings of the twenty-two chapters. These are: Introductory; Constructional Details; Fire-resisting Floor, Columns, and Doors; Reinforced Concrete Building; One-storeyed Buildings; Fire Appliances, Sprinklers, and Fire Alarms; Lighting; Heating, Ventilation, and Humidity; Calculation of Machines in Mills; Recent Examples of Mills; Steam Boilers; Boiler Appliances; Steam Engines—General; Steam Engines—Recent Examples; Accessories; Turbines; Electric Driving; Gas and Oil Engines; Gearing—Toothed Wheels; Gearing—Belt-Driving; Rope Driving; Shafting and Bearings.

It will be seen, therefore, that this book is likely to be of benefit to all who have to do with the equipment and design of general engineering works and factories, and that it is not merely of value to cotton-mill engineers. It can be recommended as such, and merits a place on every engineer's bookshelf, whence it will often be drawn as a source of up-to-date reference on matters connected with works construction and equipment.

❧

Reduction Gear for Marine Turbines.

THE illustrations herewith show the details of a remarkable spur reduction gearing invented by G. W. Melville and J. H. Macalpine, and which has been under test for some time at the works of the American Westinghouse Electric Company at Pittsburg. With the exception of the wheels themselves, which were obtained in Germany, the construction of the gear was carried out at the Pittsburg works. The general appearance of the gear, which has for its object the translation of the high relative speed of the efficient turbine into the more moderate speed which is imperative in the use of the screw

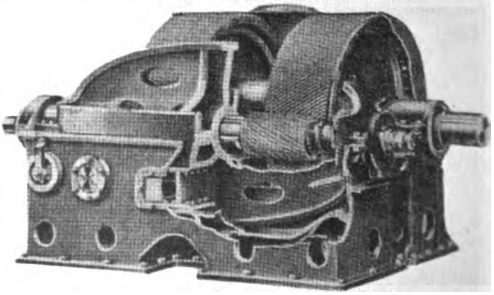

FIG. 1. COMPLETE GEAR WITH FRAME BROKEN TO SHOW PINION AND FLOATING FRAME.

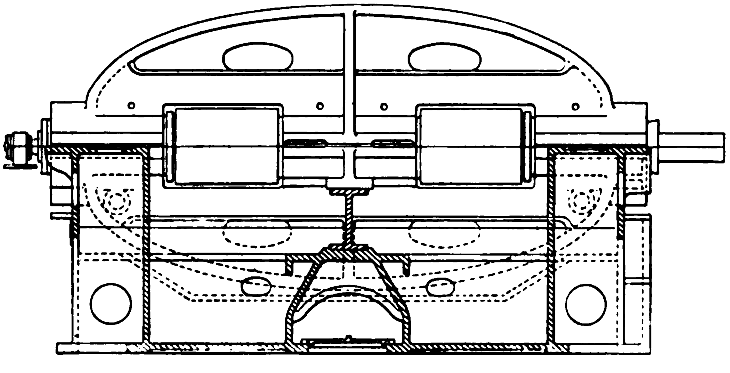

FIG. 2. SIDE ELEVATION IN SECTION SHOWING SUPPORT OF FLOATING FRAME.

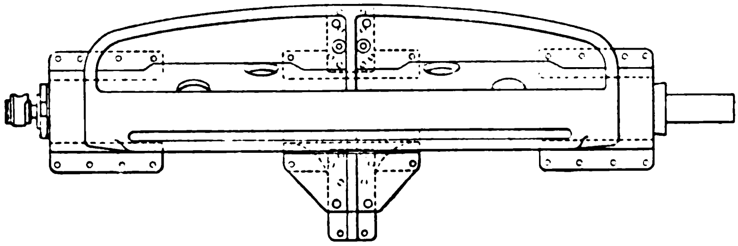

FIG. 3. PLAN OF PINION SHAFT AND FRAME.

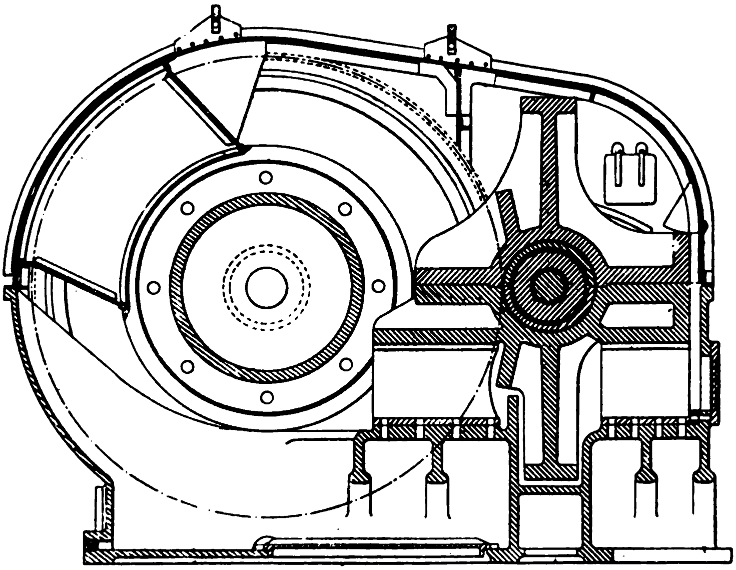

FIG. 4. END ELEVATION IN PART SECTION THROUGH FLOATING FRAME.

propeller, is illustrated in Fig. 1. It will be seen that it resembles the well-known De Laval arrangement of a divided helical gear, one-half of which is right- and the other half left-handed. The smaller gear or pinion is supported in three bearings in a heavy steel "floating frame," which is supported at the middle of its length by a heavy I-beam resting upon a raised portion of the base of the enclosing and supporting gear case.

In Figs. 2, 3, and 4 the device is shown in section, plan, and elevation, where the relation of the supporting I-beam to the pinion shaft is clearly shown.

The floating frame is a heavy steel casting flexibly mounted in the gear box and supporting the pinion shaft in rigid bearings, but in such a way that it will allow this shaft to have a slight longitudinal freedom so that it can slide axially to and fro within the frame. In the elevation of the floating frame (Fig. 2) will be seen the flexible I-beam which is supported by the bed plate. The pinion, it will be seen, is supported in three bearings, the centre bearing dividing the two pinion faces, one of which is right-handed and the other left-handed, the gear being much larger and stiffer than the pinion, requiring only two bearings. The floating frame is made deep vertically so as to be stiff enough to withstand deflection by the vertical forces at the bearing. It is also stiffened in the horizontal plane to obviate deflection from the horizontal forces. The floating frame plan is shown in Fig. 4. Fig. 5 shows the pinion shaft in section and the flexible shaft by which it is driven. At the end of the shaft is the coupling driven by the turbine shaft, while the other end of the flexible shaft is coupled to the extreme end of the pinion shaft on the inside by means of keys and bolts. This interior shaft is so flexible that it imposes practically no constraint on the pinion and floating frame, and it is evident that both as to its longitudinal position in the floating frame and in the angular position of the axis the pinion is solely under the control of the forces transmitted through the teeth of the gears, and it is evident that the pressure on the faces of the teeth would tend to keep the pinion and gear in alignment. But, if for any cause, such as wear, or heating of bearings, or any other disturbing influence, the alignment is affected, the I-beam on which the floating frame is supported acts as a hinge allowing the frame to yield to the extent necessary to correct the deflection.

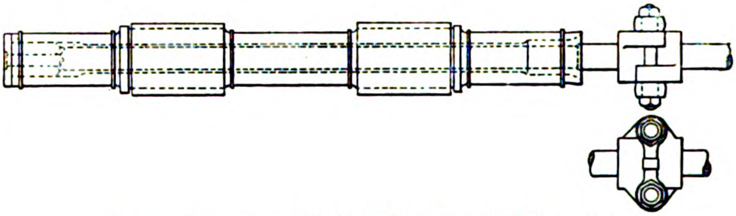

Fig. 5. Pinions and Shaft showing Driving Connection.

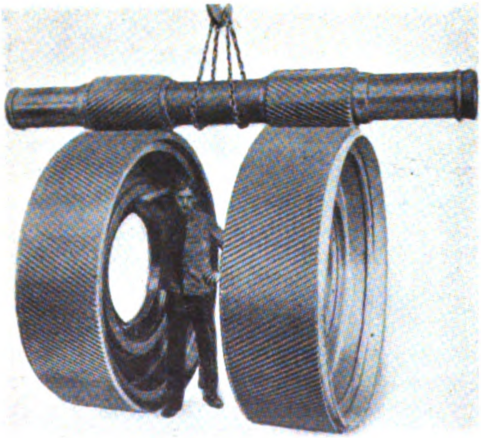

Fig. 6. The Pinions and Gear Wheels.

Fig. 5 shows the hollow pinion shaft with its internal driving shaft connected to the far end of the pinion shaft, while its other end is connected to the turbine shaft by the flexible coupling shown in plan and elevation. This coupling consists of two flanges, one of which is keyed to each shaft and connected to each other by links which allow considerable longitudinal freedom.

The gear wheels and pinions were cut and hardened by Shuchardt and Schütte, of Chemitz, Germany, from steel forgings of 90,000lb. tensile strength furnished by Messrs. Krupp, of Essen. A very good idea of their size and proportion may be had from Fig. 6, which is a reproduction of a photograph taken just previous to their shipment from Germany.

* * *

The Brussels Exhibition.

THE Brussels International Exhibition of next year is being very strongly supported by many countries, but of all nations Germany is apparently making the most gigantic efforts to outclass all other exhibitors. Our great competitor is practically building a complete exhibition on her own account. While, for instance, the other nations are content to share a common hall for their railway engineering exhibits, Germany is building a separate pavilion entirely for her own material. Germany's position is exceptional, too, in another respect, inasmuch as the whole of the ground taken up by her belongs to her, while all the rest of the ground, except those parts occupied by main halls and pavilions, has been let to an English company, which again sublets the spaces for refreshment booths, champagne kiosks, restaurants, side-shows, &c.

France has a fine hall or pavilion. It is very roomy, and is much more tastefully decorated than the German building. The French exhibits, too, promise to be very fine and of great variety.

Other countries which have separate pavilions are Italy, Spain, with a fine brick structure, the Netherlands, and Luxemburg. The Balkan States are going to exhibit too, but there is not yet much to be seen of their products.

As far as we ourselves are concerned, a very considerable space will be occupied by our exhibits, and it never was more desirable than it is at the present time that our manufacturers should make a good show if we wish to maintain the premier position among industrial nations. As is well known, Brussels is a great centre of traffic, and arrangements are being made on a large scale in anticipation of a heavy influx of visitors. A number of large new hotels have been completed within the last few months, such as the Palace, the Carlton, and the Astoria hotels among others. The older hotels are being extended and renovated. A new railway station has been built close to the exhibition, nine new tramway routes have been constructed leading to the same place, and several hundred extra motor cabs will be put in commission.

Belgium is a wealthy country with a great capacity for buying, and its engineers have a keen appreciation of the best in workmanship and high-class productions; as it is, they now prefer English goods to others, but it is very necessary that we should show them what we can do in this competition.

An Internal Combustion Pump.

On 19th Nov., before a very crowded meeting of the Institution of Mechanical Engineers, Mr. Herbert A. Humphrey read an extremely interesting paper on the "Internal Combustion Pump" which he has invented. The author has produced a gas-driven pump of great simplicity and strength, in which the force of the explosion acts directly on the surface of the water. The energy transmitted to the water suffices not only to drive a quantity of the fluid against a delivery head, but a portion of the water swings back and, like a piston, drives out the exhaust gases. On the return swing it creates a vacuum and sucks in the fresh mixture; then it swings back again and compresses the gas, which is exploded, and the whole cycle repeats itself. The water, therefore, acts as piston and flywheel. Moreover, and this is the point of great importance, it acts like an engine piston with a variable stroke; on the explosion or working stroke the water moves forward until the pressure above the surface of the water is practically equal to atmospheric pressure. On the return stroke it practically fills the whole explosion chamber, thus scavenging with great completeness; the second out-stroke (induction) is much shorter than the working stroke, and the second return stroke (compression) shorter still. The result of expanding the burnt products down to atmospheric pressure gives a thermo-dynamic cycle of much greater efficiency than the ordinary gas engine or Beau de Rochas cycle. Another important point is that no trouble is to be looked for in the high temperatures caused by exploding large quantities of gas, as is the case with large gas engine cylinders. The economy, safety, and simplicity of the pump are remarkable, and it is perhaps not too much to say that the perfection of this engine promises to revolutionise our engineering methods in many directions. Space does not permit of a detailed description of the pump, but we might notice the author's suggestion for a gas-driven central station where the pump is employed to drive a low-pressure water turbine direct coupled to the generator; with a producer he estimates that even in a small station the fuel consumption per Board of Trade unit would be 2lb. of anthracite coal, while the lubricants, stores, and repairs bill for the pump itself are almost nil. An appendix to the paper gives a summary of Dr. Unwin's report on the tests carried out. In his conclusion he says that the results show a higher efficiency than in any pumping arrangement, driven by gas engine or steam engine, hitherto recorded. Comparing a centrifugal pump driven by a gas engine, Dr. Unwin gives the following figures:—

Gas engine and centrifugal pump, 120 to 127 cubic feet of gas per p.h.p.
Humphrey gas pump, 83.1 cubic feet of gas per p.h.p.

Working with a small lift scarcely affects the efficiency of the Humphrey pump, whereas both steam and gas engine driven pumps become very inefficient at low lifts. Several other comparisons are made with steam engines of different types where the coal consumption per p.h.p hour was 1.996lb., 1.662lb., and 1.695lb. in the three steam pumps, while the Humphrey pump used 1.061lb. per p.h.p. hour.

Graphite as a Lubricant and Protective Coating for Ironwork.

SOME two years ago it was announced in America that Dr. E. G. Acheson, who is also responsible for the invention of carborundum, had succeeded in producing a graphite of very high purity and an almost molecular degree of fineness by a process involving the use of the electric furnace and sundry methods of treatment, of which the details are not public property. In addition to the extreme purity and fineness which resulted from the process, it was stated that Acheson deflocculated graphite, as it is termed, would remain permanently suspended in oil, an achievement which up to that time, and indeed since, has never been attained with flake or ordinary mineral graphite.

The discovery aroused some interest, as it was seen that if it were possible to employ a mixture of oil and graphite for general lubrication a considerable monetary saving might be effected owing to the cheapness of the latter, and at the same time fuller advantage might be taken of a material which is known to be a most excellent lubricant. The success attained in America by the Acheson product—which is the only artificial graphite on the market—encouraged the company to extend their operations to Great Britain, and their various manufactures are now obtainable direct through their British agents.

The introduction of Acheson graphite to this country has rendered available many interesting particulars of which hitherto only rumours have been heard. For instance, with regard to its mixture with oil, so long as the latter is mineral and of a good quality free from acid, the suspension of the minute graphite particles is permanent, and it is therefore now possible to employ a proportion of graphite for all classes of lubrication and for any engine—steam, gas, oil, or petrol—by the ordinary means of sight feeds, wicks, drips, or splash. To some extent from the point of view of cost, and to a large extent from that of efficiency, this is a highly important advance, particularly where internal combustion engines are concerned, as it is here that the benefits of graphite are most manifold.

Reports from eminent authorities, and in particular one from the Technical Committee of the Automobile Club of America, state definitely that owing to the film of graphite which adheres to the piston, cylinder walls, and valves, thus filling up all irregularities and producing a perfect fit and polish, compression in gas and oil engines is considerably increased. For this reason and also because when employing graphite as an auxiliary it is only necessary to use about half the quantity of oil, the objectionable smoke from the exhaust is diminished or entirely stopped. In addition, it is further claimed that there is a saving in internal friction of about 25 per cent., and that if through accident the oiling gear should get out of order the engine will run for a considerable time on the graphite film in its bearings without injury of any kind.

The means by which the deflocculated graphite is introduced to the ordinary oil are novel. Tubes or cans are supplied containing a paste termed "Oildag," consisting of 0.35 of one per cent. weight of graphite and a good mineral oil. Each can holds a quantity of paste sufficient to charge a given amount of oil, and when the two are mixed the resulting lubricant, which now contains the graphite in suspension, is ready for use in the ordinary way.

In addition to lubrication in the above form and that of a mixture with grease, Acheson graphite is being extensively used in the shape of a paint for the preservation of ironwork of all kinds and for wood. For this purpose it has a minimum purity of 90 per cent., which is a very important feature. Mr. A. Humbolt Sexton in his work, "Corrosion and Protection of Metals," emphasises this, pointing out that the success of graphite as a paint is almost entirely dependent upon purity both in the pigment and the oil. A really good paint of this nature properly applied has a life which may extend to fifteen years, and so perfect is its contact with the metal that it cannot be sweated off. Cost, too, is in its favour, as experience has shown that besides being easier and cheaper to work owing to the lubricating nature of the pigment, the cost for material per square yard of painted surface works out at 0.5d. as against 0.6d. for the best quality of iron oxide paint and 0.7d. for red or white lead. Graphite paint has sometimes been objected to upon the score of its colour, which is a dark steel grey, and which cannot be altered by the addition of pigments without seriously impairing its quality. This, fortunately, is a difficulty that is very easily overcome by the simple expedient of using the graphite as a priming coat, finishing off with ordinary paint of any colour that may be desired.

There is no doubt whatever that in addition to lubrication there is a great future for graphite as a paint pigment now that it is possible to secure it in a high state of purity at a lower cost than oxide or lead paint. It is rapidly coming into increasing use for structural ironwork, bridges, &c., and excellent examples of its use in the latter sphere are found in the King Edward VII. bridge over the Tyne, the Armstrong bridge, and the Ouseburn viaduct at Newcastle.

◆

The Problem of the Prime Mover.

REVIEWING engineering progress, there is no feature more prominent than the rivalry, accompanied by an ever-advancing rate of progression, between the leading types of power generators. Reciprocating steam engines, steam turbines, gas engines, oil engines—all are developing, and all have reached a remarkably fine degree in the three essentials of engine design: reliability, fuel economy, and flexibility. Every few months sees some noteworthy improvement made in one or other of these methods of power generation, either in the design of the engine itself, or in a novel combination of the types to serve one purpose, or in adding some external device or appliance which directly assists the engine in one or more of the three essentials named.

It is not so very long ago that there seemed to be a widespread opinion that the steam turbine would rapidly oust the reciprocating steam set altogether. This opinion was doubtless largely due to the extensive advertising of the great economies of fuel and floor space, &c., which attended its use, and not a little merely to "fashion." It was really "up-to-date" to have an engine which never developed a knock, which had neither valves nor rods nor cranks, no packing, no cylinder lubrication, &c., which only used about 15lb. of steam per kilowatt-hour, and which, because it spun merrily round at 1500r.p.m. or more, could be comfortably placed in the crank chamber of its ponderous cranked rival, which weighed at least four times as much. Practice showed, however, that it was not such a great blessing to have speeds of thousands of revolutions per minute; even the dynamo maker has found this a limitation hard to cope with; the marine engineer gave it up as a bad job, and had, perforce, to reduce the turbine speed, and in doing so sacrificed something of the, to him, particularly attractive steam economy. It was proved also that for the general run of high-pressure steam work the reciprocating engine fully maintained its position as an equally, or slightly more, economical steam user.

The internal combustion engine, whether using coal, natural, blast-furnace, or coke-oven gas, alcohol, petrol, paraffin, or heavy oils, is obviously the type which ensures a greater heat efficiency than any steam-driven motor could be expected to give. Its limitations have been chiefly mechanical; large sizes, high temperatures, complex mechanism, and all the well-known troubles following the directing of an explosive flame to useful service have been the hindrance to its development. As to how far experience has overcome these defects is evident in the modern examples of internal combustion engines which are doing perfectly good service; in small sizes on motor-cars, in large sizes in some of the most important electric stations, steel works, and collieries, and also on shipboard.

It will thus be seen that each of the three types of power generator is so far developed as to leave little to choose between them. There are, of course, local considerations or special conditions of service which in particular cases render the use of one type or other obligatory; but taking the subject in a general way and for the majority of installations where any type may be used, the decision no longer rests to any marked extent upon the merits of the particular type of prime motor. The problem has become much more complex.

For electric power generating service the reciprocating engine is to hold its ground at the expense of the turbine as the most efficient machine for working with high-pressure steam; on the other hand, the turbine is undoubtedly the only really efficient machine for utilising low-pressure steam as a power agent. The consequence is that combined high-pressure engine and low-pressure turbine plants are in vogue. But reciprocating engines without turbines, and working non-condensing, even at considerable back-pressures, are likely to become a fashion in public electric supply practice. It only needs one of our electric lighting companies to tackle the house-to-house heat distribution question as described elsewhere in this number to see a return made generally to the old-fashioned simple engine dynamo sets of the early electric light station. Oil engines, particularly those of the type which are "self" igniting and use heavy crude oil fuel, are being put down in increasing numbers for the larger private electric installations, as are also gas engines of the several types. It is not improbable that the near future will see a marked increase in the number of central stations adopting internal combustion engines. In fact, it is rather strange that the superior merit of the internal combustion engine plant for widely-varying load service, it having no stand-by losses and a well-maintained efficiency at all loads, has not resulted in its being adopted more often than has been the case. The reason for this in very many instances has undoubtedly been the impression that such plant was not reliable. This has given way in face of practical experience, and hence it is the more reasonable to anticipate its considerable use in future.

Turning now to marine engineering, where also the reciprocating steam engine has been threatened, and displaced to some extent, by steam turbines and internal combustion engines, we see also that the tendency of future practice is towards combinations of two or more types of power generators, or one type with some device or medium interposed between it and the ship propeller. It is only by virtue of light weight, ease of control, and a very fine degree of fuel economy that any new method can displace the reciprocating marine engine.

The turbine entered the field by reason of its small size per unit power, but its best speed is too high for the propeller, and as a result it has to be built to run at such comparatively low speeds that its value as an economical machine is greatly lessened. Moreover, the turbine is non-reversible—the most serious drawback of any to its general adoption for direct ship propulsion.

To remedy these defects there are two schemes now prominently in evidence. One of these is described and illustrated in this number—it is simply the design of an exceptionally high-power, high-speed spur reduction gear which will allow the turbine to retain its best high speed and the propeller its most effective low speed. Possibly with modifications such a gearing could be arranged for securing an effective reverse drive of the propeller.

The other and probably by far the superior method, in that it permits of a steady full-speed running of the turbine and a wide range of propeller speeds in either direction instantaneously brought into play as desired and from any convenient part of the vessel, is the insertion of a dynamo-motor system between the turbine and the propeller. Readers will be familiar with this system, which was exhaustively described in our issues of April, May, and October of this year. Although neither the gearing method nor the electrical method has so far developed that it has gone a-sailing, in both cases there is every prospect of an early trial under real service conditions, and this is particularly so with the electrical method, which lends itself to fairly conclusive experiments being made on land. These have been made, and the results would seem to warrant the fitting of a vessel at any time.

Owing to the very small space occupied by the highly efficient oil engine and its fuel supply, and the avoidance of boilers, funnels, and upper-deck impedimenta attending its use, the internal combustion engine is receiving the very greatest attention from marine engineers to-day. In this issue is a brief illustrated description of a new marine oil engine which possesses the long-sought feature of reverse running. It does not need any lengthy dissertation to indicate that as such this engine will of a certainty largely displace the coal-consuming steam engine on the smaller types of vessel, and it may possibly be taken up for some vessels of considerable size. It would seem, however, that the most promising of all methods now available for large ocean-going vessels is the combination of oil engine and electricity, which combination gives every advantage now sought for in the generation and application of power for ship propulsion.

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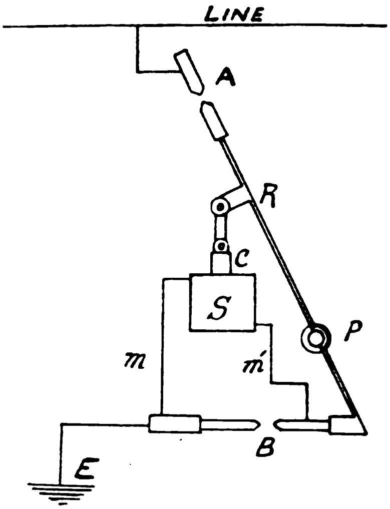
Lightning Protector for High-tension Aerials.

"LA ENERGIA ELECTRICA" describes an interesting form of lightning protector for use with overhead lines of transmission pressures up to 50,000 volts. The accompanying figure indicates the arrangement. A connection is made from the line to a spark gap A, the lower point of which is fixed to an inclined balanced rod R, pivoted at P. At the foot of R is one terminal of a second spark gap B, which is in series with A. The fixed terminal of B is connected direct to earth. S is a solenoid shunted across the spark gap B, and M and M′ are flexible connections. C is a plunger working in the solenoid; the plunger is linked to the balanced rod at R.



The action is as follows: When the surge takes place it sparks across at A and at B and goes to earth, the solenoid being unaffected by the high-frequency currents. Once there is an arc at A the line current follows the surge, and having only a low frequency it finds the gap at B of higher resistance than the solenoid; it therefore passes through the latter to earth. In passing through the solenoid the current causes the core C to be sucked down, thus increasing the gaps at A and B until the arc is broken. The apparatus is said to be very sensitive and to work well.

"Sentinel" Air Compressors.

UNDER this title Messrs. Alley and MacLellan have issued an attractive catalogue in which their several types and sizes of air compressors are illustrated and described in detail. The catalogue is a very complete one, giving particulars of outputs, dimensions, weights, and prices of compressors, and also supplementary particulars of other "Sentinel" products and of recent works, extensions, shipbuilding orders, &c. The new catalogue is well produced, and will be found useful by all general engineers.

◆

"Holophane" Globes.

EVERYONE is familiar with "Holophane" glass ware as used for effective and striking illumination purposes. Messrs. Siemens's latest illustrated list dealing with these specialities embodies several new patterns, and gives many reductions in price. In thus bringing "Holophane" glass ware more prominently before electric light consumers and the trade generally, this list will serve as an aid to efficient illumination. Messrs. Siemens state that they are prepared to overprint a supply for any bona-fide electrical dealer or contractor with his name and address on receipt of trade card and reference to this notice.

INDEX TO VOL. XII.

July to December, 1909.

A

Acceleration in Colliery Winding, 129
Accumulator Railway Cars, 115
Air Compressors, "Sentinel," 380
Alcohol from Wood Refuse, 308
Alldays Blowers, 318
Argentine, Engineering Trade in the, 306
Argentine Republic, Trade in the, 112
Artesian Wells for Works, 214
Artificial Loads for Large Generators, 138
Ashes and Smoke-Box Breeze, Locomotive, 46
Auto-Converter, The "C.M.B.," 35
Automatic Regulation of Temperature of Electric Furnaces, 126
Automatic Typewriting, 255
Awards, Cowper-Coles, 320

B

Ball and Roller Bearings, 169, 209
Bearings, Ball and Roller, 169, 209
Bearings, Friction Reducing, 353
Belt Horse-power Diagram, A, 142
Birkenhead Corporation Tramways, 132
Blower, Large Electric, 312
Blowers, Alldays, 318
Board of Trade and the Brussels Exhibition, The, 55
Brazil, Wireless Telegraph Station in, 248
British Machinery Trade, 248
Brusio Hydro-Electric System, The, 299
Brussels Exhibition, The, 374
Brussels Exhibition, The Board of Trade and the, 55
Buenos Aires, Exhibition at, 187

C

Cableway, The Wetterhorn Electric, 106
Canada, Chromium and Tungsten Ores in, 253
Canada, Peat and Iron in, 116
Cascade, Induction Motors in, 100
Catalogue Standardisation, Trade, 309
Central Stations, Public Heat Supply from, 328
Chain Drives, Large, 117
Chromium and Tungsten Ores in Canada, 253
"C.M.B." Auto-Converter, The, 35
Coal and Iron Industry in Germany, The, 182
Coal and Self-Ignition, Stored, 309
Coke-Oven Gas Electric Plant, 114
Collieries, Dust Prevention in, 126
Condensers for Electric Power Circuits, 113
Constant Current Electric Traction, 350
Continuous-Current Turbo-Dynamos, The Design of, 204, 265
Converter, The "C.M.B." Auto, 35
Corrosion in Steel, Sulphur as a Cause of, 179
Costing System for Engineering Works, A Job Card and, 145
Cotton-Mill Engineering, 372
Couplings, Flexible, 185
Cowper-Coles Awards, 320
Cunard Notes, 190

D

"Denny" Gold Medal, The, 246
Design of Continuous-Current Turbo-Dynamos, The, 204, 265
Diesel Marine Engines, Sulzer, 343
Drying of Transformer Oil, The, 192
Dust Prevention in Collieries, 126

E

Electrical Instruments, New, 62
Electric Blower, Large, 312
Electric Cableway, The Wetterhorn, 106
Electric-Driven Rolling Mills, 42
Electric Motor-Car Costs, 311
Electric Motors for Machine Tool Service, Standardising, 369
Electric Operation of Pit-Heap Haulage, 244
Electric Postal Service, 116
Electric Power in Textile Factories, 126
Electric Power Shovels, 179
Electric Propulsion of Ships, The, 236
Electric Railway Results, The St. Clair Tunnel, 184
Electric Rolling Mills, 246
Electric Shaft Furnace at Domnarfvet, Sweden, The, 220
Electric Sprinkling-Car, A Large, 367
Electric Steel Furnaces, 31
Electric Submarine, An, 123
Electric Traction, Constant Current, 350
Electric Winding System for Mines, A New, 122
Electrification of Canadian Grand Trunk Railway, 182
Electrification of Main Line Railways in France, 313

Electro-Hydraulic Riveter, 19
Electro-Metallurgy at the White City, 118
Endless Railway, The Revival of the, 324
Engineering, Cotton-Mill, 372
Engineering, Shipbuilding and Marine, 11
Engineering Trade in the Argentine, 306
Engineering Works, A Job Card and Costing System for, 145
Engines, "Sentinel," 307
Engines, Sulzer Diesel Marine, 343
Evolution of Wire, The, 144
Exhaust Steam Turbo-Generator, a 5000kw., 181
Exhibition at Buenos Aires, 187
Exhibition, The Board of Trade and the Brussels, 54
Exhibition, The Brussels, 374
Exhibition, The Japan-British, 1910, 318

F

Fibre, Insulating, 59
Fire Appliances, 64
Flexible Couplings, 185
France, Electrification of Main Line Railways in, 313
Friction Reducing Bearings, 353
Furnace at Domnarfvet, Sweden, The Electric Shaft, 220
Furnaces, Automatic Regulation of Temperature of Electric, 126
Furnaces, Electric Steel, 31

G

Galvanised Iron, The Testing of, 285
Gas Electric Plant, Coke-Oven, 114
Gas Engines, Producer, 304
Gear-Cutting, Recent Practice in, 5
Gears, High-speed Reducing, 120
Generators, Artificial Loads for Large, 138
Germany, The Coal and Iron Industry in, 182
Globes, "Holophane," 380
Gold Medal, The "Denny," 246
Grand Trunk Railway, Electrification of Canadian, 182
Graphite as a Lubricant and Protective Coating for Ironwork, 376

H

Haulage, Electric Operation of Pit-Heap, 244
Heat Supply from Central Stations, Public, 328
Heavy Motors for Wood-Pulp Grinding, 367
High-Carbon Steel, Power Requirements for Rolling, 91
High-speed Reducing Gears, 120
High-speed Steel Tools, 216
High-tension Main Line Railways, Short-circuit Experiments on, 317
H.M.S. "Nubian," 57
"Holophane" Globes, 380
Home Market Metal Prices for the Past Three Months, 124, 188, 250, 314, 370
Hydro-Electric System, The Brusio, 299

I

Induction Motors in Cascade, 100
Induction Steel Furnaces in the States, 187
Instruments, New Electrical, 62
Insulating Fibre, 59
Internal Combustion Pump, An, 375
Iron in Canada, Peat and, 116
Iron Industry in Germany, The Coal and, 182
Iron, The Testing of Galvanised, 285
Ironwork, Graphite as a Lubricant and Protective Coating for, 376

J

Japan-British Exhibition, 1910, The, 318
Jigs and Jig Design, 257
Job Card and Costing System for Engineering Works, A, 145

L

Lamp, A New Tantalum, 118
Lamp, The Quartz, 245
Large Chain Drives, 117
Large Electric Blower, 312
Large Electric Sprinkling-Car, A, 367
Large Power Plant Order, 318
Lightning Protector for High-tension Aerials, 379
Loade, The, 10
Loads for Large Generators, Artificial, 138
Locomotive Ashes and Smoke-Box Breeze, 46
Lubricant and Protective Coating for Ironwork, Graphite as a, 376

M

Machinery Trade, British, 248
Machines, Tapping, 59
Machine Tool Service, Standardising Electric Motors for 369
Machine, Twist-Drill Testing, 60
Machine Vices, 331
Machine Wave-Forms and Transmission Efficiencies, 252
Marine Engineering, Shipbuilding and, 11
Marine Engines, Sulzer Diesel, 343
Marine Propulsion by Producer-Gas, 254
Marine Turbines, Reduction Gear for, 372
Mercury Arc Rectifier, The Theory and Commercial Use of the, 344
Metal Prices for the Past Three Months, Home Market, 124, 188, 250, 314, 370
Microphone, New Long-Distance, 320
Milling and Milling Cutters, 73
Mines, A New Electric Winding System for, 122
Modern Valves, 193, 272
Montreal Sub-station, The, 110
Motor-Car Costs, Electric, 311
Motor-Cars, Speed Alarm for, 62
Motors for Machine Tool Service, Standardising Electric, 369
Motors for Wood-Pulp Grinding, Heavy, 367
Motors in Cascade, Induction, 100
Motor Starter for Printing Machines, 119

N

New Electrical Instruments, 62
New Electric Winding System for Mines, A, 122

New Long-Distance Microphone, 320
New Tantalum Lamp, A, 118
Novel Steamship Design, 247
"Nubian," H.M.S., 57

O

Oerlikon Steam Turbine, The, 289
Ores in Canada, Chromium and Tungsten, 253
Orr, Watt, & Co., Ltd., Motherwell, The Works of, 83
Ozone in Ventilation, 310

P

"Pallion," The Steam Collier, 187
Paris Metropolitan Railway, The, 24, 65
Peat and Iron in Canada, 116
Peru, Progress in, 180
Photo-Telegraph, The Sémat, 249
Pit-Heap Haulage, Electric Operation of, 244
Postal Service, Electric, 116
Power Consumption of Reversing Rolling Mills, 252
Power Plant at the Imperial Wharves, Wilhelmshaven, Steam Turbine, 321
Power Plant Order, Large, 318
Power Requirements for Rolling High-Carbon Steel, 91
Power Scheme, The Rhone Falls, 1, 316
Power Supply of Rio de Janeiro, The, 164
Prices for the Past Three Months, Home Market Metal, 124, 188, 250, 314, 370
Prime Mover, The Problem of the, 377
Printing Machines, Motor Starter for, 119
Problem of the Prime Mover, The, 377
Producer-Gas Engines, 304
Producer-Gas, Marine Propulsion by, 254
Progress in Peru, 180
Projectors, Searchlight, 156
Propulsion by Producer-Gas, Marine, 254
Propulsion of Ships, The Electric, 236
Public Heat Supply from Central Stations, 328
Pulley, A Simple Friction, 60
Pump, An Internal Combustion, 375

Q

Quartz Lamp, The, 245

R

Railway Cars, Accumulator, 115
Railway Results, The St. Clair Tunnel Electric, 184
Railway, The Paris Metropolitan, 24, 65
Railway, The Revival of the Endless, 324
Railways in France, Electrification of Main Line, 313
Railways, Short-circuit Experiments on High-tension Main Line, 317
Recent Practice in Gear-Cutting, 5
Recorder, A Steam Economy, 96
Reduction Gear for Marine Turbines, 372
Reversing Rolling Mills, Power Consumption of, 252
Revival of the Endless Railway, The, 324
Rhone Falls Power Scheme, The, 1, 316
Rio de Janeiro, The Power Supply of, 164
Riveter, Electro-Hydraulic, 19
Roller Bearings, Ball and, 169, 209
Rolling High-Carbon Steel, Power Requirements for, 91
Rolling Mills, Electric, 246
Rolling Mills, Electric-Driven, 42
Rolling Mills, Power Consumption of Reversing, 252

S

St. Clair Tunnel Electric Railway Results, The, 184
Searchlight Projectors, 156
Sémat Photo-Telegraph, The, 249
"Sentinel" Air Compressors, 380
"Sentinel" Engines, 307
Shipbuilding and Marine Engineering, 11
Ships, The Electric Propulsion of, 236
Short-circuit Experiments on High-tension Main Line Railways, 317
Shovels, Electric Power, 179
Showrooms and Stores, Siemens' New, 316
Siemens' New Showrooms and Stores, 316
Simple Friction Pulley, A, 60
"Simplex" List, The, 368
Speed Alarm for Motor-Cars, 62
Sprinkling-Car, A Large Electric, 367
Standardising Electric Motors for Machine Tool Service, 369
Steam Collier "Pallion," The, 187
Steam Economy Recorder, A, 96
Steam Turbine Power Plant at the Imperial Wharves, Wilhelmshaven, 321
Steam Turbine, The Oerlikon, 289
Steamship Design, Novel, 247
Steel Furnaces, Electric, 31
Steel, Power Requirements for Rolling High-Carbon, 91
Steel Tools, High-speed, 216
Stored Coal and Self-Ignition, 309
Stores, Siemens' New Showrooms and, 316
Submarine, An Electric, 123
Sub-station, The Montreal, 110
Sulphur as a Cause of Corrosion in Steel, 179
Sulzer Diesel Marine Engines, 343

T

Tantalum Lamp, A New, 11
Tapping Machines, 59
Telegraph Station in Brazil, Wireless, 248
Temperature of Electric Furnaces, Automatic Regulation of, 126
Testing of Galvanised Iron, The, 285
Textile Factories, Electric Power in, 126
Theory and Commercial Use of the Mercury Arc Rectifier, 344
Thorium Flint, 249
Time Limit Device, 115
Tools, High-speed Steel, 216
Traction, Constant Current Electric, 350
Trade, British Machinery, 248
Trade Catalogue Standardisation, 309
Trade in the Argentine, Engineering, 306
Trade in the Argentine Republic, 112
Tramways, Birkenhead Corporation, 132
Transformer, A 500,000-volt, 313
Transformer Oil, The Drying of, 192
Transmission, A 110,000-volt, 233
Transmission Efficiencies, Machine Wave-Forms and, 252
Tungsten Ores in Canada, Chromium and, 253
Turbine Power Plant at the Imperial Wharves, Wilhelmshaven, Steam, 321
Turbine, The Oerlikon Steam, 289
Turbines, Reduction Gear for Marine, 372
Turbo-Alternator, 11,200h.p., 111
Turbo-Dynamos, The Design of Continuous-Current, 204, 265
Turbo-Generator, A 5000kw. Exhaust Steam, 181
Twist-Drill Testing Machine, 60
Typewriting, Automatic, 255

V

Valves, Modern, 193, 272
Ventilation, Ozone in, 310

W

Wave-Forms and Transmission Efficiencies, Machine, 252
Wells for Works, Artesian, 214
Wetterhorn Electric Cableway, 106
White City, Electro-Metallurgy at the, 118
Wilhelmshaven, Steam Turbine Power Plant at the Imperial Wharves, 321
Winding, Acceleration in Colliery, 129
Winding System for Mines, A New Electric, 122
Wireless Telegraph Station in Brazil, 248
Wire, The Evolution of, 144
Wood-Pulp Grinding, Heavy Motors for, 367
Works, A Job Card and Costing System for Engineering, 145
Works, Artesian Wells for, 214
Works of Orr, Watt, & Co., Ltd., Motherwell, The, 83
World's Progress in Electrical and General Engineering, The, 55, 110, 179, 244, 304, 367

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